Bond University

DOCTORAL THESIS

Improving the project delivery success of Australian construction project management practice.

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Award date:
2020

IMPROVING THE PROJECT DELIVERY SUCCESS OF AUSTRALIAN CONSTRUCTION PROJECT MANAGEMENT PRACTICE

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Submitted in total fulfilment of the requirements of the degree of

Doctor of Philosophy

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April 2020

ABSTRACT

Notwithstanding several studies on project success and many popular project models and frameworks that have been developed, there is still a great deal of uncertainty as to what constitutes a successful project delivery. Measuring project delivery success has always been a challenge for both professionals and academics since there is currently no consensus about a collection of success criteria that can be applicable to all types of projects. Enabling organisations to evaluate project success would play a key role in the field as it allows them to develop more efficient project management mechanisms and to increase the efficiency of their projects.

To fill this gap in knowledge, this research pursues a validated and systematic 3D integration project delivery success model for the Australian construction industry. This sector plays a crucial role in the Australian economy, accounting for around 10% of Australian jobs. The construction business is marked by a high rate of failure; thus, success has always been the ultimate goal of any project in this field.

The research study adopts a mixed-method research design carried out through a multi-case study strategy. The 3D Integration model is applied to 40 construction projects across Australia to calculate the project delivery success (PDS) score for each project, and the projects are ranked. The triangulation method is used to verify the results via a questionnaire survey that targets the performance of the same projects by collecting the experiences of senior managers of the collaborating organisation who have good knowledge of all their projects. This culminates in another ranking based on what is now called performance assessment review (PAR) scores. There is a strong correlation between PDS and PAR scores. Finally, the director of the collaborating organisation approved the rankings of the projects and the outcomes arising from the study data.

The results of this research demonstrate that the 3D integration model is accurate and effective in evaluating the organisation's performance across a variety of construction projects, irrespective of size, location and date. Evidence indicates that three common key performance indicators within the 3D integration model, namely value, speed and impact, can dramatically improve the probability of project success, and these are the key fields that project managers should focus further on in order to achieve better outcomes. Furthermore, PDS can be used at interim stages of project delivery to ensure that decision-making is aligned to success expectations, effectively replacing use of traditional earned value analysis.

Keywords: Project Success, Construction, 3D Integration Model, *i3d3,* Project Delivery, Critical Success Factors, Key Performance Indicators

DECLARATION

This thesis is submitted to Bond University in fulfilment of the requirements of the degree of *Doctor of Philosophy*.

This thesis represents my own original work towards this research degree and contains no material which has been previously submitted for a degree or diploma at this University or any other institution, except where due acknowledgement is made.

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DECLARATION OF AUTHOR CONTRIBUTIONS

The following papers arising from this thesis have been peer-reviewed and published during the period of candidature:

Ghanbaripour, AN, Langston, C & Yousefi, A 2017, 'Implementation of 3D Integration Model for Project Delivery Success: Case Study', *Journal of Construction Engineering and Management,* vol. 143, no. 8, pp. 1-13.

Ghanbaripour, AN, Sher, W & Yousefi, A 2018, 'Critical success factors for subway construction projects – main contractors' perspectives', *International Journal of Construction Management,* vol.20, no. 3, pp. 177-195.

Langston, C, **Ghanbaripour**, AN & Arqoub, MA 2018. 'Measuring project success: conceptualizing a new approach applicable to all project types', *The 42nd Australasian Universities Building Education Association (AUBEA) 2018 Conference: Educating Building Professional for the Future: Innovation, Technology and Sustainability, in the Globalised Market - Curtin University, Singapore, Singapore, September 2019*, pp. 107-20.

ETHICS DECLARATION

The research associated with this thesis received ethics approval from the Bond University Human Research Ethics Committee (BUHREC). The ethics approval number is 16014.

ACKNOWLEDGEMENTS

Completing my PhD degree has probably been the most challenging mission in my whole life. This thesis could never exist without the advice, encouragement and continuous support of many people whom I would like to acknowledge.

I would like to express my special appreciation and thanks to my advisor Professor Craig Langston who has the substance of a genius. Today, as I look back at how my dreams have materialised into reality, you stand clearly in my mind. You patiently listen to my challenges, understand them and motivate me to push harder in life. You always, and I mean it, always offer me the best solution possible to any problem I bring to you. There is nothing I can do to repay you adequately for your contribution to my life. I promise to always cherish your lessons, and hopefully, one day be as inspirational to others as you are to me. Also, thanks for the support that allowed me to attend project management conferences in Australia and Singapore.

I would also like to express my deepest gratitude to Associate Professor Greg Skulmoski, my colleague and second supervisor, for his guidance throughout this research, for his patience with my endless and sometimes irrelevant questions, and for continually reminding me to take my professional experience seriously. You have been a great mentor to me, and your knowledge, experience, and wisdom is a constant source of inspiration. It is indeed great to have the opportunity to work with you.

I am genuinely grateful to my parents, Rezvan and Aman, to my sister, Shafagh, and my friends all over the globe who supported and encouraged me to complete this project. Mom and Dad, thank you for helping me in all my pursuits and inspiring me to follow my dreams. I have always known that you believed in me and wanted the best for me. You are amazing parents, and you are wonderful friends.

I would like to thank my colleagues at Bond University for their encouragement as I have worked through this process. They provide me with a warm, family-like atmosphere. I enjoyed a lot of morning teas and discussions with them about project management and how to manage a full-time teaching load alongside a part-time PhD over the past three years. Special thanks also to Prof. Derek Carson, Prof. Raoul Mortley, A/Prof. Damian Cox, A/Prof. Daniel O'Hare, Dr Dane Miller, Prof. Alan Patching, A/Prof. Daryl McPhee, Mandei Saranah, Lyn Hathaway, Dr Lisa Marlow and my friends Muath, Ranka, Waled, Rosemarie and others at Bond University.

I would also like to acknowledge those project managers and practitioners who took the time to support my research, respond to my questions, and encourage me.

I would like to acknowledge my examiners. Thank you for your time and effort in reading this thesis and for giving me feedback to continue improving as a researcher.

Last but certainly not least to my wife, Sara. Where do I begin? You supported me from the outset, you believed in me, you encouraged me, you loved me, and you shared your life with me. For that, I owe the greatest thanks of all. Sara is my best friend and a life partner. Thank you for listening, providing advice, helping, distracting, and understanding. You supported me every single day on this journey, and it is now my turn to push you forward in your PhD studies because I hope to be Drs together soon.

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ABBREVIATIONS

Abbreviation	Meaning
ABS	Australian Bureau of Statistics
CII	Construction Industry Institute
CFC	Complexity Forecasting Cube
CSFs	Critical Success Factors
KPIs	Key Performance Indicators
PAR	Performance Assessment Review
PDS	Project Delivery Success
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
TBL	Triple Bottom Line

CHAPTER 1: INTRODUCTION

1.1 RATIONALE

Projects today have become the key means of development, and through efficient technological, tactical and strategic methods, they unlock the opportunities of this process. Companies are advancing their influence by spending more resources to deploy project management processes. Hence, success in achieving better outcomes in projects is providing competitive advantage in the marketplace.

Measuring and analysing project success based on a variety of criteria has been proposed and discussed by researchers for many years, although there is still no final agreement on what constitutes a successful project (Belout & Gauvreau, 2004; Besner & Hobbs, 2006; Bizan, 2003; Carvalho et al., 2015; Davis, 2014; Davis, 2018; Dvir et al., 2003; Gray, 2001; Kendra & Taplin, 2004; Lipovetsky et al., 1997; Mir & Pinnington, 2014; Nixon et al., 2012; Serrador & Turner, 2015). Furthermore, professional institutes such as the International Project Management Association (IPMA) and the Project Management Institute (PMI) have developed many methods, tools and techniques through bodies of knowledge to equip professionals with robust project success measurement tools (PMI, 2017). For many years, delivering project outcomes on time and within budget with all requirements fulfilled has been the main concern of project managers (Ika, 2009).

Dr Martin Barnes is credited with the notion of the main criteria that underpin successful delivery of projects. He promoted cost, time, and scope (output) as the famous iron triangle (or triple constraint) in measuring the success of project management. Yet, there has been an increasing disagreement among project management academics and practitioners that this conventional ideology is incomplete since it only focuses on limited project success criteria (Andersen, 2014; Langston, 2013; Musawir et al., 2017). As the purpose of projects transforms from product creation to value creation (Winter et al., 2006), these criteria need to expand so that they represent the full range of value delivered by the project. Thus, they should comprise not only project outcomes but also benefits (Musawir et al., 2017).

A considerable percentage of projects undertaken do not meet their original objectives (APM, 2015; PMI, 2015; The Standish Group, 2016). In Australia, only 23% of the firms frequently deliver successful projects (AIPM & KPMG, 2018), and globally, only 40% of project goals are in line with their respective organisational strategy (PMI, 2014). This is largely worrying at a time when there is increasing pressure on the project manager (PM) from top management to ensure project benefits accumulate to the funding organisation, as well as contribute to implementing organisational strategies (Lappe & Spang, 2014; Mir & Pinnington, 2014).

Despite much scientific activity and the tireless efforts of practitioners, and the surging interest in the field of project management that has led to the founding of professional organisations such as IPMA and PMI and several scientific journals dedicated to the field of project management, numerous project outcomes continue to disappoint their stakeholders (Dijksterhuis & Silvius, 2017; Ika, 2009). To fully understand the reasons for the failure of these projects, researchers have investigated a variety of aspects involved in project management, including how projects are carried out and the internal and external factors of the environments in which projects are being undertaken (Berssaneti & Carvalho, 2015; Papke-Shields et al., 2010).

Over the last three decades, many authors have used exclusive lines of research to pick out the factors, variables or conditions leading to successful project outcomes (Berssaneti & Carvalho, 2015). As noted earlier, the core concept of almost all methods is Barnes’ Iron Triangle (Albert et al., 2017; Cao & Hoffman, 2011; Chan & Chan, 2004; Chang, Artemis et al., 2013; Gemünden, 2015; McLeod et al., 2012; Serra & Kunc, 2015; Serrador & Turner, 2015). As Albert et al. (2017) state, there are different classifications and interpretations on project success. Various concepts in this regard have been developed, such as critical success factors, success criteria, project management success, product success, short and long-term success, etc. Critical success factors (CSFs) are the most cited concept among the researchers in the field (Berssaneti & Carvalho, 2015; Fortune & White, 2006). CSFs and the other concepts are used and discussed widely in this research, especially in the literature review; however, a short introduction on each of them is needed at this juncture.

CSFs are those elements within the project that can be directly influenced by project management in order to increase the chance of success in projects (Andersen et al., 2006). These key factors might be revised occasionally but mostly stay constant throughout the project (Creasy & Anantatmula, 2013). At the other end of the list, there are project success criteria. These are the criteria to be used in order to assess the success of a project (Albert et al., 2017; Atkinson, 1999; Westerveld, 2003). These well-accepted, objective and measurable criteria are normally developed based on the usual constraints of time, budget, and compliance with specifications standards (Aga et al., 2016). Some researchers hold the view that project management success is the main factor in project success, measured at project completion, and is traditionally based on whether the product is delivered on time, within budget, and up to the required functionality (Atkinson, 1999; Serrador & Turner, 2015). They argue that project management success should be considered as the main element of project success, because the latter is hardly achievable without it (Radujković & Sjekavica, 2017; Soon Han et al., 2011).

Product success is another aspect of success, and a distinction should be made between it and project management success, as they are in fact completely different. Conceptually, determining project management success might not comprise product success, e.g. a project is managed efficiently, but the product does not meet the client's requirements at the end of the day (Heravi & Ilbeigi, 2012; Shenhar et al., 1997).

Project success might be measured from a short-term or long-term perspective, so that on one day a project might be viewed as a success and on another day as a complete failure (Albert et al., 2017; Kloppenborg et al., 2014). For example, while commissioning a project deliverable may be achieved, it may prove to be defective or not accepted by the market during service. Hence, there is the realisation that evaluation of project success takes place at various points of time in public perception (Albert et al., 2017; Turner, 2009).

1.2 PROBLEM STATEMENT

Indeed, the evaluation of project success varies among stakeholders due to their various reasons for undertaking a project (Albert et al., 2017; Davis, 2017). Researchers in the area of project success are in agreement on the fact that the judgment of project success is dependent on the viewpoint taken (Bryde & Robinson, 2005; Koops, 2016; Müller & Jugdev, 2012; Rashvand & Zaimi, 2014). In recent research by Albert et al. (2017), they undertake a structured literature review on the topic of the evaluation of project success. They examine similarities within the assessment of project success in various areas of application and also claim that this is the very first overview of its type despite project success being a commonly scrutinised subject in project management research. They look at six different fields of application and extract the hallmark project success criteria. In this study, they assume that project success comprises project management success, product success and performance in the long run. What they find is a world of inconsistency. Their conclusion is 'a generic model to describe project success should be developed to provide a common guideline for assessing' (Albert et al., 2017). Hence, new perspectives, new performance indicators, along with a new language are necessary in evaluating the project's overall performance and success (Ika, 2009; Turner, R. & Zolin, 2012).

According to Bronte-Stewart (2015), a new paradigm is always welcomed, although there is still support for the old ones. As explained earlier, there is still much confusion about what a successful project is, since often the criteria applied are not made clear at the outset and the boundaries for what is to be included in the evaluation become blurred.

1.3 RESEARCH AIM AND OBJECTIVES

Project delivery success (PDS) is defined as the outcome of the process of project implementation, and may be described as 'doing the project right'. It does not include pre-implementation activities associated with project selection, design decision-making and financial support, nor post-implementation activities associated with operational performance and end-user satisfaction. However, it is recognised that project success is a broader term and must take into account all three aspects. PDS, therefore, is a subset of project success.

The author is working with a team of researchers, under the leadership of Professor Craig Langston at Bond University, to develop a project success model capable of comparing and ranking any type of project regardless of size, location or date. This model is known as *i3d3* and is fully described in Appendix 1.

The aim in this research is to develop a robust approach to the project Implement phase of *i3d3* based on earlier work and capable of assessing success for any type of project, and then test this approach to measuring PDS using real case studies provided by a major project management consultancy practice in Australia. All of the projects evaluated relate to various types of infrastructure, reflecting the expertise of the selected practice, albeit exhibiting different size, location and date characteristics. The tests triangulate PDS against an independent assessment of the systems in place to manage projects (a surrogate for organisational maturity) as well as the more subjective opinion of success from the perspective of the organisation's leader.

To achieve this, a number of objectives must be met:

1. To systematically review the literature on project success and the challenges practitioners face in the Australian construction industry
2. To explore and compare all the existing models that claim to measure project success to determine the best approach moving forward
3. To describe a generic framework for measuring PDS for application in the broader *i3d3* model based on Objective 2

4. To test this framework's ability to evaluate relative performance for a collection of real case studies displaying different characteristics
5. To validate the framework based on triangulation with other indicators of successful performance
6. To discuss the results of the research and report on ways in which PDS provides new insight and opportunities that can consistently realise better project outcomes

1.4 RESEARCH PLAN AND METHODOLOGY (OVERVIEW)

The research plan, as agreed at the outset, is shown in Figure 1. It has been utilised as a road map over subsequent years; however, the author was open to change, as some aspects of the research were still evolving.

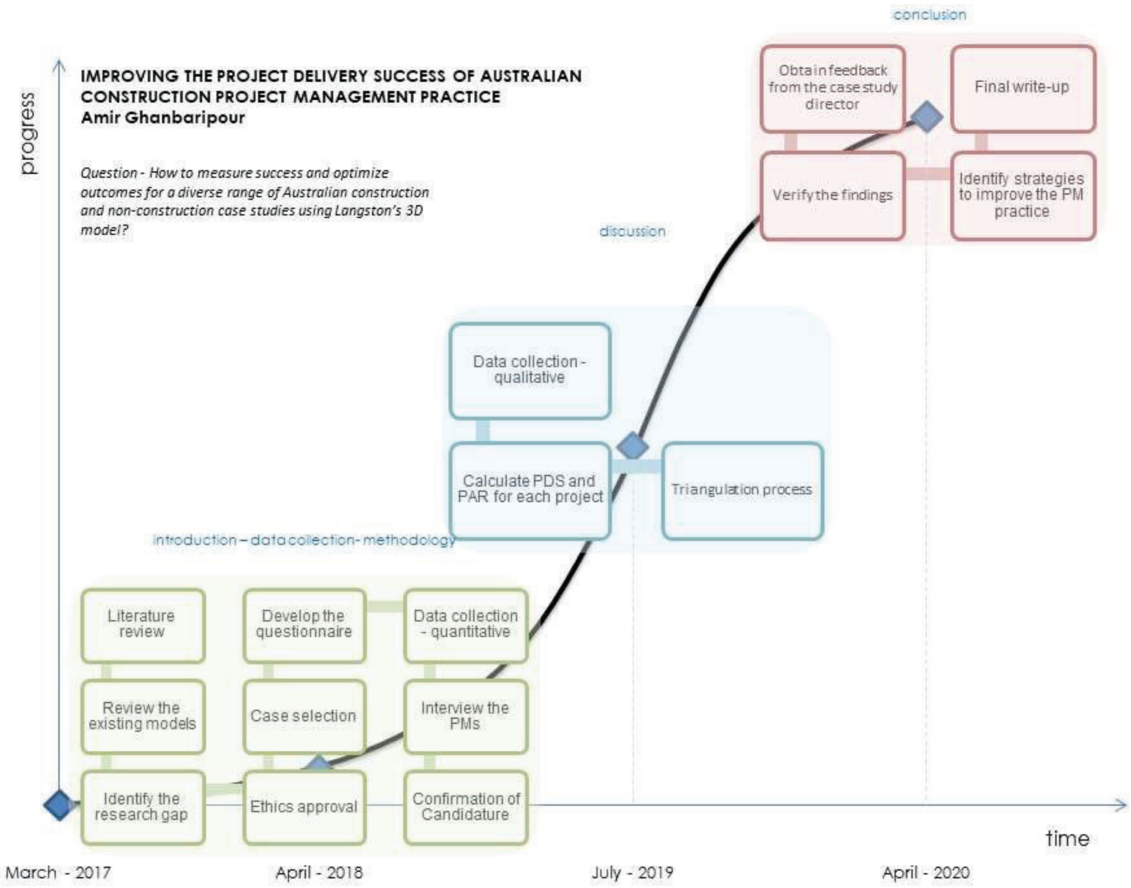


Figure 1. Research Road Map

The approach of this study is based on a mixed-method research design consisting of quantitative and qualitative data collection in order to use a triangulation technique to verify the findings. First, the research gap is identified through a comprehensive literature review. After obtaining ethical approval, 40 case studies are examined through multiple interviews and meetings. Two sets of data are collected on the same set of projects leading to the calculation of project delivery success (PDS) and performance assessment review (PAR) scores. The correlation between these two variables is analysed, and the findings presented to the director of the case study organisation to obtain his opinion. At the end, the 3D integration model is tested, and the results are discussed, interpreted and concluded to provide a set of recommendations for improving the practice of project management.

1.5 THE SIGNIFICANCE OF THIS STUDY

Current project management practices in the public construction industry sector, in particular, do not always lead to favourable outcomes (Alias et al., 2014). Success has invariably been the final goal of each activity, and a construction project is no exception. However, the construction field is distinct from other sectors of the economic system and is characterised by high rates of failure (Elattar, 2009). As a cannonading investment-led sector, it plays a major role in any country's economy (Meng & Fenn, 2019).

In the last few decades, the rapidly growing and complicated global business environment, including intensified competition among organisations, has highlighted the value of performance evaluation in projects (Neely, 2005). Despite the research conducted previously on project delivery success of construction projects, there is still a need for a model applicable to all types of projects regardless of size, location and date.

Hence, this research contributes to a larger model called *i3d3*, which is based on the idea that the key to success is measuring benefit realisation. The key characteristics of *i3d3* are that it has three-time phases, different sets of primary stakeholders (who perform the evaluation of success), different criteria per phase that should be generic across all project types, different methods of assessment per phase, and an overarching focus on measuring benefit realisation that leads to positive collective utility.

1.6 RESEARCH SCOPE AND LIMITATIONS

Research restrictions are the structural or methodological constraints that affect the interpretation of study results and are beyond the researcher's control (Merriam & Tisdell, 2016). Restrictions inherent to the case study approach are identified for this mixed-method multiple case study research. This research has a limitation on sample size. For this study, no more than 40 case studies could be reviewed since no other company could be found that was willing to share such critical data, despite significant efforts made by the researcher. Nonetheless, the number of case studies complied with guidelines from Boddy (2016) to provide adequate units for multiple case research. This study is also restricted to construction projects in Australia, and the results drawn from the findings may be subject to geographical and industrial limitations in other jurisdictions.

This researcher investigates PDS in the context of the construction industry. It can help to improve performance in this sector leading to higher efficiency and optimisation of resources. Nevertheless, the same approach can be applied to other project types (non-construction) and used to compare and rank the success of any type, as is the case in *i3d3*, but this broader application is beyond the scope of this thesis.

1.7 STRUCTURE OF THE THESIS

This thesis contains six chapters. A description of the thesis framework is presented in this section.

Chapter 1 provides the rationale and context of the research project, the problem statement, the aims and objectives of the research, the research plan and an overview of the methodology, the significance of the study and its scope and limitations.

Chapter 2 explores the literature associated with project success and develops the study's theoretical underpinnings. It includes an overview of the Australian construction industry as the context of the research, the concept of project success, its criteria, CSFs and key performance indicators (KPIs). Then, the main project success models that researchers have developed in the last three decades are reviewed to determine the research gap that exists in current knowledge.

Chapter 3 explains the methodology, including research design, application of the case study approach and triangulation technique, the process of data collection and the procedures for data analysis.

Chapter 4 outlines the results of the interviews and the questionnaires for each project, including PDS and PAR scores, scope, time, cost and risk levels, as well as the six generic KPIs and complexity factors. A statistical analysis of the results is also presented.

The research results are discussed and interpreted in Chapter 5. First, the project rankings are provided based on PDS and PAR scores, and then triangulated against feedback from the director of the case study organisation. Issues with data confidence, the impact of complexity, the characteristics of the successful projects and the role of the project management office (PMO) are made. A comparison between commonly used earned value analysis (EVA) techniques and the 3D integration model is explored to determine the possibility of using PDS in lieu of conventional EVA to measure success during the implementation of projects rather than upon handover.

The study is concluded in Chapter 6 by presenting the main findings, reviewing the aims and objectives of the research and the study's implications for practice. Also, the availability of *i3d3* software and further research possibilities are discussed.

The next chapter reviews the underpinning literature and explores the topic of project delivery success to highlight the knowledge gap and chart the way forward to resolve it.

CHAPTER 2: LITERATURE REVIEW

2.1 THE PURPOSE OF THIS CHAPTER

In order to provide the necessary theoretical background to accurately pinpoint the research gap that this study attempts to cover, and to deliver a deeper understanding of the research problem, a comprehensive literature review specifically focused on project success is performed. This chapter begins with a close look at the Australian construction industry and then reviews the literature on project success with an overarching focus on success models and the challenges in distinguishing success from failure in projects. These project success models are explored, providing the rationale for adopting Langston's 3D integration model (Langston, 2013) in this empirical research. The 3D integration model, based on the CSFs of cost, time, scope and risk, is extended to cater for different levels of project complexity. The identified knowledge gap is used to guide the remainder of the research.

2.2 AUSTRALIAN CONSTRUCTION INDUSTRY

2.2.1 OVERVIEW

The construction sector in Australia is one of the largest growing industries across the nation. Commercial construction work is anticipated to expand, and did so by 9.3% in 2018 (Cartwright, 2018). Hence, such a rapidly growing industry keeps demanding a larger portion of overall GDP, utilising more resources, creating more jobs and contributing more to the Australian economy (Cartwright, 2018).

This industry comprises different services, ranging from designing, planning and surveying to construction and services, finishing and fit-out. This industry generates over $350 billion in income, delivering around 8% of Australia's GDP, and is expected to have a projected yearly development pace of 2.5% per annum into the future (AISC, 2019).

Hughes (2017) sees project cost overruns as the most critical challenge that the construction industry has confronted for years. This affects the sector and arises from the fluctuations in material prices, bank interest rates and the value of the Australian dollar. For example, Melbourne's wholesale fruit and vegetable market, as a high-profile infrastructure project, cost twice as much as its planned $230 million budget according to the Victorian Auditor-General's Report in 2012. Similarly, the Epping to Chatswood rail project in Sydney went over budget by $300 million (New South Wales Audit Office, 2010), Perth Arena actual cost came to nearly $480 million comparing to the planned $160 million (Western Australia Auditor General, 2010), and ASIO central headquarters' construction in Canberra finished with a cost overrun of nearly $40 million (ASIO, 2011).

The most famous case is the Sydney Opera House project, which was supposed to cost $7 million in 1957 but ended up 14.5 times that, or $102 million, 16 years later (Newton et al., 2014). In Victoria, the Victorian Economic and Financial Statement highlighted similar 'next to failure' projects in 2011, which referred to '*a range of capital projects beset by inadequate management and very significant cost overrun*'. It was estimated that approximately $2 billion worth of cost overrun was wasted, and then later in 2016 the detrimental factors causing this damage was identified by agencies to be due to design and scope changes (VAGO, 2016). Likewise, there are some other well-known projects that were delivered (mostly on time and within budget) under a public-private partnership that are deemed as failures, such as the M7 Clem Jones Tunnel, Brisbane's River City Motorway, Sydney's Cross City Tunnel and Melbourne's Southern Cross Railway Station (Love et al., 2016; Regan et al., 2015).

Table 1 illustrates examples of time and cost variations on some well-known Australian projects.

Table 1. Examples of Cost and Time Variations in Well-known Projects in Australia

Project Name	Time variation	Cost variation	Procurement method
Melbourne's wholesale fruit and vegetable market	6 years	$230 million	Memorandum of Understanding (MOU)
Sydney's Epping to Chatswood rail project	3 years	$300 million	Construct, Lump Sum
Perth Arena	31 months	$389 million	Construct only with design and construct elements
ASIO Main Office	11 months	$40 million	Traditional
Sydney Opera House	16 years	$95 million	Traditional

2.2.2 MAIN CHALLENGES IN THE AUSTRALIAN CONSTRUCTION INDUSTRY

Focusing on Australian construction projects, Doloi (2013) examines the root causes behind the poor cost performance from the perspective of the three key participants; namely clients, consultants and contractors working on a wide range of projects comprising residential, commercial, and industrial buildings. The conclusion is that thorough control processes, robust planning, effective site management and design are the CSFs of such projects and any weakness in the early stages of the project, especially in the planning and scheduling procedure, drastically affect the project leading to cost overruns.

Another investigation is carried out in Australia on cost overruns and failures in construction project management by Shah (2016), which attempts to provide a clear understanding of current practices and the cost and management issues that exist. He focuses on the identification of the critical factors affecting cost overruns in the Australian construction industry. Nearly 160 respondents with relevant background and experience ranging from clients, consultants and contractors are targeted. Similar to those of Doloi (2013), the findings indicate that the most dominant factors in cost overruns in Australia are: (1) planning and scheduling deficiencies, (2) construction methods, and (3) effective controlling, monitoring and feedback process (Shah, 2016).

Looking at a large sample of Australian transport infrastructure projects over the period 2001 to 2015, Terrill et al. (2016) discovers traces of systematic cost overruns in such projects. Further investigation by Terrill & Danks (2016) into the budget performance of all 836 projects valued at $20 million or more and planned or built during that time reveals that a minor number of projects (17%) that exceeded their planned budget by more than half caused 90% of Australia's cost overrun problems. Additionally, they state that 11% of cost overruns on transport infrastructure projects in Australia are triggered by scope changes. Considering other sources of deficiencies and complications in the construction industry, Campos Gutierrez et al. (2013) remark that, as expected, one of the most significant contributors to disputes is the construction industry since it is one of Australia's largest and most important industries.

The Australian Bureau of Statistics records that in 2004-2005 nearly half of the total industry conflicts are associated with the construction industry. However, this dispute percentage drops to 27% in 2008, compared to other sectors (ABS, 2010; Campos Gutierrez et al., 2013). Where did all these disputes come from? Campos Gutierrez et al. (2013) make an attempt to answer this question, and by reviewing 78 documented historical court cases related to construction disputes, they found that the five most frequent reasons are damages, negligence, timing, payments and variations.

Another issue that the Australian construction industry is dealing with, and is strongly related to project success, is labour productivity, which can be addressed by improving project management practice (Shehata & El-Gohary, 2011). Li & Liu (2012) investigate the growth in the labour productivity level of the Australian construction industry. In their research, a single-input and single-output system demonstrate the numerical results indicating that the average labour productivity levels of the construction industry per annum elevate slowly in all the Australian states and territories. However, despite the overall growth, the year-on-year labour productivity levels experience fluctuations over the period 1990–2008.

In another study, trying to address the main challenges in managing multiple project environments (MPE) in the Australian construction industry, Ismah Hashim & Chileshe (2012) conduct a survey that discovers the most significant issues in managing such projects. They mainly comprise three key aspects – organisational culture, resource allocation and competencies of project manager – and include 'commitment and responsibility, leading projects, planning, conflict and communication, availability of resources and feedback'.

A large portion of the construction projects in Australia happen in remote areas (Hay et al., 2017), and the issues in such projects should also be considered when attempting to improve project management practice. Other researchers (e.g. Baroudi & McAnulty, 2013) examine remote Australian construction sites that display considerable growth, looking for the challenges these projects face. It came to their notice that most issues arise in the area of staff recruitment. They note that to address such issues, which can be detrimental in many ways, long-term strategic thinking by the contractors working in such projects is required.

Also, careful attention should be paid to the social ramifications of construction activity. 'T*he production and costing results showed productivity, procurement and delivery and pricing as potentially problematic, requiring reasonable initiative and planning* […] *problems were also highlighted within the need for adequate infrastructure and communications*' (Baroudi & McAnulty, 2013, p.10).

Despite such problems, many firms in the Australian construction industry have achieved remarkable outcomes including the Sydney Harbour Tunnel, the International Terminal at Brisbane Airport, the Anzac Bridge, and Sydney's Star City Casino. Sydney's Olympic Stadium started staging events in March 1999, well ahead of the Games in 2000 (Sauer et al., 2001). However, there are and have been projects suffering from various detrimental factors leading to cost overrun, rework, and not-good-enough outcomes.

Speaking of detrimental factors in the Australian construction industry that improved project management can address, Love & Li (2000) reviews the performance and contracts of two case studies including a residential project and a warehouse project in Australia. They find that the rework costed 3.15% and 2.40% of each project's contract value respectively. Construction changes and errors form almost half of the rework changes in their investigations (Love &

Edwards, 2005). In another study, it was discovered that the mean direct and indirect cost of rework, in a sample of 161 construction projects, was 6.4% and 5.9% of the planned budget, respectively (Love & Edwards, 2005).

Improvements in project management can also affect productivity: another area worthy of consideration. According to Hughes & Thorp (2014), considering that the construction sector is a foremost contributor to GDP in the economic system of Australia and performs an influential role in national financial growth, an overview of the productivity of this industry helps to understand its impact. In their research, a group of experienced construction project managers working on a broad range of projects in Queensland rank 22 primary and 25 secondary factors that could have an impact on construction productivity. Their findings suggest that the main factors affecting the construction productivity most include rework, supervisor competence and incomplete documentation.

2.2.3 PROJECT MANAGEMENT IN AUSTRALIA

Crayon et al. (2017) provide a detailed chronicle of the project management history in Australia. They state that, in the 1970s, project management started to develop and broaden in Australia from building works to defence and aerospace fields. Tools and methods such as work breakdown structures were implemented in project management. With interest rates rising during that period, a significant increase in costs made it necessary for the project teams to focus on cost control and project delays. In the 1980s, a professional project management body of knowledge (*PMBOK® Guide*) was published by PMI. This best practice knowledge database improved project managers' expertise and knowledge within their teams. It was around this period that project managers started signing up for courses to acquire relevant certification. Practitioners could now see the entire project concept and process life cycle. Between 1990 and 2005, companies began integrating strategies for project management into their organisations, and businesses were searching for project teams to help incorporate new techniques and upgrade their information technology infrastructure. In 1990, also, a chapter was founded in Australia by PMI.

In most countries, project success is normally measured through the three main constraints of time, cost, and scope of works, and the Australian construction industry is no exception (Hughes, 2017). Most of the professionals working in this sector hold this view, as Baccarini & Collins (2004) demonstrate via a survey among a sample of 150 members of the Australian Institute of Project Management (AIPM). They believe that success criteria narrow down to these three factors. Baccarini & Collins (2004) argue that it is worrying, and they pinpoint an urgent need for more research and also education for this sector to develop knowledge on other success criteria that can have significant impacts on project outcomes. It is worth mentioning that their survey indicates that the most important success criterion is the product criterion for meeting the customer's needs. This implies that Australian project management practitioners are aware of the need to ultimately satisfy the customer's requirements.

To achieve such a prominent goal, the project team should collect all the requirements from the client and establish rigorous scope and quality management processes. Another result of their survey, which is in line with other studies, is that project management success may improve product success and lead to higher customer satisfaction levels. They suggest that of project management performance index comprising time, cost and output should be continuously under review by the project team, and its implied influence on product success reported.

Abbasi & Jaafari (2018, p.4) suggest four aspects of focus for the evolution of project management:

> *1) use of project management as a vehicle to achieve organisational strategy and/or create new products and services; 2) linking and managing pre-execution (upstream) and execution (downstream) activities within a vastly extended project life cycle; 3) redefining project success criteria from traditional time, cost, scope (related to execution process efficiency) of the commercial value, its life cycle performance, and its environmental and social impacts (both positive and negative); and 4) human resource management and socio-cultural and behavioural aspects of projects*.

Table 2 summarises the main factors that can contribute to better project delivery in Australia based on the previous reviewed literature.

Table 2. Success Factors in Australian Construction Projects

Success Factor	**Reference**
Thorough control processes Robust planning Effective site management and design	Doloi (2013)
Planning and scheduling Construction methods Effective controlling, monitoring and feedback process	Shah (2016)
Scope change	Terrill & Danks (2016)
Organisational culture Resource allocation Competencies of project manager	Ismah Hashim & Chileshe (2012)
Long-term strategic thinking Social ramifications of construction activity	Baroudi & McAnulty, 2013
Reduce rework Supervisor competence Better documentation	Hughes & Thorp (2014)
Customer satisfaction	Baccarini & Collins (2004)
Competence project management Effective linkage between project phases Redefinition of the success criteria Human resource management	Abbasi & Jaafari (2018)

Overall, in the Australian construction industry, a business-as-usual attitude is unlikely to handle the large number of new external and internal factors coming into play, especially with mounting environmental performance requirements, and to address changing social values. The successful creation, delivery and development of new solutions to several construction problems are needed if the industry is to respond appropriately to these challenges (Hardie & Newell, 2011).

In this regard, a new generic model should be available to practitioners enabling them to more effectively monitor the performance of projects and more accurately evaluate their success at every stage of the life cycle.

2.3 PROJECT SUCCESS

Table 3 provides a summary of definitions for project success, which have been defined by various researchers over time. It is worth mentioning that project success definition has also changed over time.

Table 3. Summary of Success Definitions (Hwang & Lim, 2013)

Author	Project Success Definition
Tuman (1986)	All project requirements anticipated, and needs met with sufficient resources, in a timely manner
De Wit (1986)	A project is considered an overall success if it meets the technical performance specifications or mission to be performed and results in a high level of satisfaction concerning project outcomes among key people in the parent organisation, and key people on the project team, as well as key users or clients of the finished project
Ashley et al. (1987)	Results are better than expected or normally observed in terms of cost, schedule, quality, safety, and participant satisfaction
Pinto & Slevin (1987)	A successful project fulfils four criteria: Completed on schedule (time) Completed within budget (cost) Achieved all goals originally set for it (effectiveness) Accepted and used by clients for whom the project is intended (client satisfaction)
Wuellner (1990)	A successful project: Completes on time, within budget, and with an acceptable profit margin Satisfies client expectations Produces a high-quality design or consulting services Limits the firm's professional liability to acceptable levels
Kerzner (1998)	The success of a project is defined in terms of five factors: Completed on time Completed within budget Completed at the desired level of quality Accepted by customer Customer agrees to allow the contractor to use the customer as a reference
Shenhar et al. (2001)	Most commonly, project success is the completion of the project within the specified budget, on time, and the short-run success of a business
Chan et al. (2002)	Traditionally, success can be defined as the extent to which project aims and objectives are accomplished
Pheng & Chuan (2006)	Insufficient focus on time, cost and quality since such a definition entails the measurement of project success as too objective, difficult and ambiguous due to disparity between project success and product success
Ika (2009)	When defining project success, project management success should be distinguished from project success. The former refers to efficiency and project team's internal objectives, while the latter embraces concerns for overall efficiency and effectiveness. They can also be distinguished by the measurable goals of project management success such as time and cost.

In this section, the concept of project success, together with its key topics of success criteria, CSFs and KPIs that sometimes are used interchangeably, are explored.

What does project success mean?

Initiating projects in organisations to make a change is becoming significantly common, so this question needs to be answered appropriately (Langston et al., 2018). Success means different things to different people. People from different walks of life hold different views on success. An engineer concerns the technical competence of the product, while success may encompass functional and aesthetic qualities from the perspective of an architect. The amount of money saved in the project may be the ultimate goal of an accountant, but a human resources manager feels successful when the overall levels of satisfaction are high among the staff (Freeman & Beale, 1992).

2.3.1 PROJECT SUCCESS CRITERIA

Jugdev & Muller (2005, p.19) state that '*trying to pin down what success means in the project context is akin to gaining consensus from a group of people on the definition of good art*'. A review of the literature shows that there is a continuum of project success criteria identified and developed by different researchers in various locations, which are either generic for all projects or only applicable to a particular type, size or location (Jugdev & Muller, 2005). These criteria have been developed throughout the years. However, the emphasis has always been on the main criteria of the iron triangle (Atkinson, 1999) and other measures such as overall client/owner satisfaction have later been added (Might & Fischer, 1985; Pinto & Slevin, 1987; Shenhar et al., 2001; Tukel & Rom, 2001; White & Fortune, 2002).

According to Ika (2009), a set of principles, measures or standards applied to determine or judge project success may be referred to in all types of projects as project success criteria. A formula that is supported by all stakeholders and is simple, unequivocal, and easily applicable to all projects, should be proposed to resolve the problem of how to measure project success (Dvir et al., 2003; Pinto & Slevin, 1987).

As mentioned earlier, time, cost and scope (variously termed output or quality) were the first success criteria proposed in the field. However, some researchers hold the idea that the scope criterion comprises meeting technical/functional specifications. Quality seems to be a subjective concept that is vague and multidimensional that would imply different meaning to different individuals, especially the key stakeholders of the project (Ika, 2009; Wateridge, 1998). In this regard, some have moved on and replaced it with the scope criterion (perhaps including quality) as one of the primary elements of project success in most industries (Tukel & Rom, 2001).

Seven main project success criteria for business ventures are introduced by Freeman & Beale (1992), including technical performance, the efficiency of execution, managerial and organisational implications (including customer satisfaction), personal growth, and manufacturer's ability and business performance. Lipovetsky et al. (1997) suggest that project success in defence projects should be measured in four aspects of meeting design and planning goals, customer benefits, benefit to the developing organisation, and benefit to the defence and national infrastructure.

Several years later, in Australia, Baccarini & Collins (2004, p.1) conclude from a survey conducted among project managers from various industries that project success criteria comprise two main components – product success and project management success:

> *Project Management Success – this focuses on the project process and has three criteria:*
>
> 1. *meeting time, cost and quality objectives,*
> 2. *quality of the project management process, and*
> 3. *satisfying project stakeholder needs where they relate to the project management process (primarily project owner and project team).*

Product Success – this deals with the effects of the project's final product and has three criteria:

1. *meeting the project owner's strategic organisational objectives (goal);*
2. *the satisfaction of users' needs (purpose);*
3. *the satisfaction of stakeholders' needs where they relate to the product (primarily customer/user).*

Shenhar et al. (2001) argue that short-term and long-term project goals need to be considered when success is being measured, since projects are strategic. Mir & Pinnington (2014) link project success in general with a competitive advantage in a framework that includes the following factors, where the aspects proposed are dependent on time and the project's technological uncertainty: 1) efficiency (meeting schedule and budget goals); 2) impact on customers (customer benefits in the performance of end products and meeting customer needs); 3) business success (project benefits in commercial value and market share); and 4) preparing for the future (creating new technological/operational infrastructure and market opportunities).

Following this line of research, Diallo & Thuillier (2004) highlight the necessity for breaking up the activity and people-oriented dimensions in assessing project outcomes. This method considers stakeholder satisfaction in international development projects in order to utilise elements other than the traditional cost, time and scope criteria. These other elements include the practicality of the products to the funding organisation, the appeal of the outcomes to the stakeholders, the learning process and experience achieved through learning, the motivation for future projects, knowledge attainment, the process that produced the final report and its acceptance procedure, and the project closure process (Diallo & Thuillier, 2004; Khang & Moe, 2008). Some researchers have taken an approach that reduces the dimensions and aspects considered for project success. The traditional criteria of cost, time and scope are considered as incomplete in this approach. They maintain the idea that time as a variable makes these criteria excessive as it is part of project cost performance. Hence, quality aside, a cost and time interrelationship affects both so none of them can change without causing change to the other and hence they cannot be deemed as independent variables in project success measurement (Khosrowshahi, 1997; Yu et al., 2005).

Most of the success criteria identified in the literature have been developed through theoretical studies. Shokri-Ghasabeh & Kavousi Chabok (2009) state that a major contradiction exists between what is identified and discovered by the researchers in literature and the criteria and factors that practitioners consider as prominent in project success and performance evaluation. Among most of the studies reviewed, time is identified as the most important and critical factor in success. However, in the survey conducted by Shokri-Ghasabeh & Kavousi Chabok (2009), top management support is found to be the essential criterion in achieving success in all types of projects. The other interesting finding in that research is that project control appears to be a significantly important criterion that comprises the traditional criteria of time, cost and quality/scope plus risk. Additionally, 43% of the respondents in their survey believe that project success and project management success are so close that they could be considered as one concept, while the majority state that those are entirely different concepts.

As mentioned above, there are many criteria developed for different types of projects. For instance, Elattar (2009) develop a hierarchical framework utilising a set of success criteria for construction projects. These three sets of success criteria were based on three different stakeholders' perspectives, including the owner; designer; and contractor. Al-Tmeemy et al. (2011, p.341) state that:

> *The first set of criteria from the owner's perspective included: schedule, budget, function for intended use, the end result as envisioned, quality, aesthetically pleasing, return on investment, marketability, and minimised aggravation. The second set comprised the designer's perspective and consisted of: satisfied client, quality architectural product, met design fee and profit goal, professional staff fulfilment, met project budget and schedule, marketable product/process, minimal construction problems, no liability claims, socially*

accepted, the client pays, and a well-defined scope of work. The third set consisted of the criteria from the perspective of the contractor. Those criteria were, meet the schedule, profit, under budget, quality specifications, no claims, expectations of all parties clearly defined, client satisfaction, good direct communication, and minimal or no surprises during the project.

Overall, a set of project success criteria that can be applied to all types of projects cannot be retrieved from the literature. Almost all of the identified measures are based on the various professional practitioners' point of views arising from a specific type of project or context.

2.3.2 CRITICAL SUCCESS FACTORS

Although the project success criteria have been extensively explored in the previous section, when developing a project success model, it is necessary to review the CSFs in the literature as well. These success factors should be distinguished from the success criteria as they may lead the project towards achieving better outcomes but might not be able to measure success in a project continuously.

CSFs are those few things that must go well to ensure success for a manager or an organisation, and, therefore, they represent those managerial or enterprise areas that must be given special and continual attention to bring about high performance (Boynton & Zmud, 1984). Pinto & Slevin (1987) propose that although there is justification for many of recorded CSFs, the comparative significance of CSFs is subject to change at distinct stages of the project life cycle.

Several critical success factors for projects that were often theoretically based rather than empirically demonstrated were identified throughout the seventies and eighties. Not all but most of such lists typically provide factors related to the project manager as well as the organisation to which the project belongs, and appear to overlook the attributes of the project, the characteristics of the team members and externalities (Belassi & Tukel, 1996; Pinto & Prescott, 1990).

The CFSs identified in the literature from 1976 to 1987 can be seen in Table 4.

Table 4. Critical Success Factors Identified in Literature (Belassi & Tukel, 1996)

Martin (1976)	Locke (1984)	Cleland & King (1983)	Sayles & Chandler (1971)	Baker et al. (1983)	Pinto & Slevin (1987)	Morris & Hough (1987)	Kerzner (1987)	Chua et al. (1999)
Define Goals	Make project commitments known	Project summary	Project manager's competence	Clear goals	Top management support	Project objectives	The corporate understanding of project management	Adequacy of plans and specifications
Select project organisational philosophy	Project authority from the top	Operational concept	Scheduling	Goal commitment of project team	Client consultation	Technical uncertainty innovation	Executive commitment to project management	Construct-ability
General management support	Appoint a competent project manager	Top management support	Control system responsibilities	On-site project manager	Personnel recruitment	Politics	Organisational adaptability	PM commitment and involvement
Select the project team	Set up communicatio ns and procedures	Financial support	Monitoring and feedback	Adequate funding to completion	Technical tasks		Project manager selection criteria	Realistic obligations/ clear objectives
Allocate sufficient resources	Set up control mechanisms (schedules, etc.)	Logistic requirements	Continuing involvement in the project	Adequate project team capability	Client acceptance	Community involvement	Leadership	PM competency
Provide for control and information mechanism	Progress meetings	Facility support		Accurate initial cost estimates	Monitoring and feedback	Schedule duration urgency	Commitment to planning and control	Contractual motivation/ incentives
Require planning and review		Market intelligence (who is the client)		Minimum start-up difficulties	Communication	Financial contract legal problems		Site inspections
		Project schedule		Planning and control techniques	Trouble-shooting	Implement problems		Construction control meetings
		Executive development and training		Task (vs. social orientation)	Characteristics of the project team leader			Formal communi-cations (construction)
		Manpower and organisation		Absence of bureaucracy	Power and politics			
		Acquisition						
		Information and communication channels						
		Project review						

Most of the CSFs listed in Table 4 are derived from a theoretical perspective and fail to empirically prove the usefulness and contribution of such factors to projects success. Also, these CSFs are not generic, mainly related to specific industries and only concentrate on the organisational and project manager-related aspects. Hence, other domains such as external factors that may significantly affect project outcomes as well as internal factors such as project team-related aspects are lacking (Belassi & Tukel, 1996).

There are arguably two types of success factors. The first one includes objective, quantifiable, measurable and hard criteria, and the second comprises soft, qualitative, less measurable and subjective criteria (Chan & Chan, 2004; Yong & Mustaffa, 2012). Different stakeholders look for diverse outcomes in every project, which makes it hard to settle on a set of criteria that pleases everyone with different viewpoints (Phua, 2004; Toor & Ogunlana, 2009). In this regard, Lim & Mohamed (1999) make an attempt to form two main classifications for success criteria so that all possible viewpoints can be considered: macro and micro. Is the original project concept achieved? – the macro viewpoint tries to address this question and stems from the perspective of end-users, customers and other stakeholders about project success. The micro viewpoint takes care of the project success in minor component levels (Toor & Ogunlana, 2009).

The main objectives that these CFSs are identified to address are project performance in terms of cost, time, quality and the overall project satisfaction. The first aspect that looks at external and internal factors of the project, such as political and funding issues that are affected by the project's surroundings, and constructability and size. The second aspect is contractual arrangements that comprise factors that need to be considered in the initial phases of the project to avoid or mitigate the further implementation risks. The third aspect, interestingly, takes care of the stakeholders of the project who might have a different perception of project success and can have a massive impact on the project outcomes. The fourth aspect focuses on the communication and interaction among key stakeholders during the planning and control phases. They also remark that the project organisation must provide an environment where project participants can conduct interactive tasks. The CSFs and the project success criteria might change due to the size and location of the project. Nguyen et al. (2004) come up with the five most important CSFs, including:

1. competent project manager,
2. adequate funding until project completion,
3. multidisciplinary/competent project team,
4. commitment to the project, and
5. availability of resources.

Initially, they extract 20 CSFs from the literature and question the professionals working in different sectors of the construction projects, such as owners, designers/consultants and contractors/subcontractors, from which 109 practitioners ranked the most important CSFs. They employ factor analysis yielding four main components of comfort, competence, commitment, and communication.

Comfort includes factors that make sure the resources, efforts and leadership are effectively utilised in the project implementation. Competence takes care of the required soft and hard skills as well as the level of technological capability necessary to complete the project tasks. Commitment takes care of the stakeholders and ensures all project participants are effectively engaged, and harmony among all participants working at different parts of the project (planning, design, construction, operation, and management) is established and maintained. Lastly, Communication focuses on the level of clarity, transparency and effectiveness of the circulatory information system among all external and internal project participants. They state that putting more time and effort on these success factors would likely prevent the project to fail as it improves the synergy and engagement among the project team and other key stakeholders.

A construction project undertaken in a different location might have different CSFs. According to Iyer & Jha (2005), in Indian construction projects the most important CSFs include effective monitoring and feedback by the project manager and project team members, coordinating ability and rapport of project manager with top management, positive attitude of the project manager and other project participants, and the project manager's technical capabilities. They also investigate the factors that negatively affect project outcomes in India. These include poor human resource management and labour strikes, the negative attitude of the project manager and other project participants, inadequate project formulation in the beginning, vested interest of client representatives in not getting the project finished on time, and conflicts between the project manager and top management.

It has been demonstrated in the literature that quality can increasingly improve project outcomes and the business and construction sectors are no exception (Belle, 2000; Burati et al., 1992). From an extensive literature review, Metri (2005) identify ten total quality management CSFs for construction firms: namely top management commitment, quality culture, strategic quality management, design quality management, process management, supplier quality management, education and training, empowerment and involvement, information and analysis, and customer satisfaction.

Looking at stakeholder management in construction projects in Hong Kong, which may have a massive impact on project success, Yang et al. (2009) find the top three CSFs are managing stakeholders with social responsibilities (economic, legal, environmental and ethical), exploring stakeholders' needs and constraints to the project, and communicating with and engaging stakeholders properly and frequently. They classify them into five key dimensions: precondition, factor, stakeholder estimation, information inputs, decision-making, and sustainable support.

In Thailand, findings of a research conducted by Toor & Ogunlana (2009) reveal that factors related to project planning and control, project personnel, and involvement of client are critical to the success of large-scale construction projects. The 76 respondents in their study who worked at the largest construction projects in Thailand remark on the need for adequate resources, effective and sufficient communication, mutual understanding of stakeholders on project goals, and award of bids to the 'right' designers and contractors. Since sub-contractors conduct a huge proportion of work, the non-performance of any sub-contracting firms can be one of the root causes for project failure (Arditi & Chotibhongs, 2005).

In a study on construction projects in Hong Kong, Ng & Tang (2010) identify nine CFSs for labour-intensive sub-contractors, and the most important CSFs turned out to be timely completion, profit, programme/planning, cash flow, as well as management-level leadership. Since the CFSs might differ from one project type to another, they then compare the results they found from the labour-intensive projects to those of equipment-intensive ones.

Interestingly, although these two project types might require more attention on different factors, the results turn out to be the same, so the professionals working in either project types hold the same perspective on success factors.

Turkish small to medium-sized construction companies are also investigated in research by Arslan & Kivrak (2008) in which several face-to-face interviews with top managers are conducted. Their study reveals that the most important success factors include business management, financial conditions and owner-manager characteristics.

In Elwakil et al. (2009), a broad understanding of the CSFs in construction projects is provided since their research sample comprises various firms from a wide range of countries scattered across four different continents. Sixty-three respondents from Canada, Egypt, France, Greece, Germany, USA, Saudi Arabia and UAE rank and suggest the following factors as the most important for achieving success: availability of knowledge, clear vision, mission and goals, organisational structures, feedback evaluations, business experience, political conditions, research and development, employee culture environments, and competition strategy.

Other types of construction projects are those with target cost contracts. Chan et al. (2010) find the following significant factors from a survey of project participants, such as contractors, consultants and owners: the right selection of project team, the well-defined scope of work in client's project brief, and early participation of contractor in design development. Having examined the mindsets of clients towards project success and performance evaluation of Swedish construction projects, Frödell et al. (2008) state that the most relevant success factors are the engagement of the user, dedication to the project, high quality consideration among the construction workforce, and teamwork.

Kog & Loh (2012) argue that the success factors are even different in the eyes of people working in various roles on construction projects, such as civil engineers, architects, etc. In their research, they employ an AHP method and obtain the views of 27 experienced professionals revealing that adequacy of plans and specifications and project manager competency sit at the top of the success-related factors list of 10 CSFs. Others include focus on time, quality, budget, and overall performance for architectural, civil and structural engineering, and mechanical and electrical engineering works of construction projects. It is also agreed that the dedication and engagement of project managers are vital to the quality and overall performance of construction projects in all different components of civil and structural engineering, architectural, mechanical and electrical engineering.

Similar to the findings of Nguyen & Chovichien (2013) in Vietnamese project, Yong & Mustaffa (2012) identify 37 factors from the literature and had Malaysian practitioners working in different roles, including client, contractor and consultancy sectors, rank them. Findings imply that the key factors critical to project success are the interaction between hard and soft components. Hard attributes are the competence of consultants and contractors, project funding and team leaders, while soft attributes comprise solid interaction and effective communication between project stakeholders. In this sense, in considering the importance of human-related factors such as competence, commitment, communication and cooperation towards the performance of a construction project, a clear continuity in interpretation is observed among respondents.

Gudienė et al. (2014) reveal that the highest-ranking CSFs for construction projects in Lithuania are:

1. clear and realistic project goals,
2. project planning,
3. project manager’s competence,
4. relevant past experience of the project management/team,
5. the competence of the project management/team,
6. clear and precise goals/objectives of the client,
7. the value of the project,
8. the complexity and uniqueness of the project,
9. the project manager’s experience, and
10. the client’s ability to make timely decisions.

In the Libyan construction industry, things are not much different. The CSFs that Gebril (2012) identify include feedback capabilities, client experience, allowing adequate time for the project, the client's ability to make a decision, contractor experience, quality of relationships between team, leadership skills of the project manager, adequacy of funding, shortage in materials (this one might refer to sufficient materials), labour productivity, regulatory changes and building code. In another African country, Nigeria, Amade et al. (2015) explores the delivery of public sector construction projects, uncovering that appropriate planning has a substantial impact on the success of government construction projects, whereas project manager leadership skills, effective communication management, effective project coordination, efficient and efficient procurement process/method and weather conditions does not explain any failures.

Through an international survey among project managers with an average of more than 15 years project experience across the United Kingdom, United States of America, Nigeria, Australia and Canada, Tsiga et al. (2016) find that the top five most important success factors in the construction industry are: project organisation, project manager competence, project risk management, project team competence, and requirements management.

The success factors can be different on Middle Eastern construction projects. To investigate that, Gunduz & Yahya (2015) perform a survey concentrating on such projects and notice that the most significant CSFs were the technical capabilities of the company, scope and work description, control system, effective site management, project manager's capabilities and dedication, financial strength of the business, planning activities, effective scheduling, project participants' commitment, appropriate project management techniques, and adequacy of plans and specifications. In another country in the region, Iran, Ghanbaripour et al. (2018) identify the following CSFs as the most significant ones from a contractors' point of view: goal setting, top management support, project manager competency, performance management at each phase, effective allocation of workforce, adequate funding throughout the project, contractor's competence and experience, and a multidisciplinary/competent project team.

2.3.3 KEY PERFORMANCE INDICATORS

The aim of creating KPIs is to assess the performance of the project towards a number of predefined criteria (Raynsford 2000). Cox et al. (2003, p.142) state that '*KPIs are compilations of data measures used to assess the performance of a construction operation. They are the methods management uses to evaluate employee performance of a particular task. These evaluations typically compare the actual and estimated performance in terms of effectiveness, efficiency, and quality in terms of both workmanship and product*'.

KPIs inform managers how well the organisation operates in its critical success factors and enables them to improve it significantly by tracking them (Parmenter, 2015). According to Parmenter (2015), project KPIs have seven characteristics as follows:

1. *Non-Financial:* non-financial measures (e.g., not expressed in dollars, Yen, Pounds, Euros, etc.)
2. *Timely:* measured frequently (e.g., 24/7, daily, or weekly)
3. *CEO focus:* Acted upon by the CEO and the senior management team
4. *Simple:* all staff understand the measure and what corrective action is required
5. *Team-based:* responsibility can be tied down to a team or a cluster of teams who work closely together.
6. *Significant impact:* a major impact on the organisation
7. *Limited dark side:* they encourage appropriate action

From a construction project perspective, KPIs can significantly contribute to the measurement of project performance, as they allow the managers to monitor performance through various phases of the project to avoid major rework and modifications that can result in relatively high cost and time overruns in construction projects (The KPI Working Group, 2000). Therefore, to take advantage of these evaluation tools and to determine the appropriate indicators, Collin (2002) argues that the process of establishing KPIs should ideally include the following important factors:

1. KPIs need to be generic but will focus on the critical aspects of outputs or outcomes.
2. For routine usage, only a restricted and manageable number of KPIs can be maintained. Too many (and too sophisticated) KPIs can lead to time-consuming and resource-intensive outcomes.
3. KPIs must be systematically used as their value is almost entirely derived from their consistent usage in multiple projects over time.
4. The collection of data must be carried out as straightforward a way as possible.
5. To minimise the impact of project-specific variables, a large sample size is necessary. KPIs should be developed for use in any project building.
6. The criteria and performance evaluation system must be recognised, respected and owned across the company to ensure that success assessment is effective.
7. Modification and refinement are unavoidable since KPIs might evolve throughout the project.
8. KPIs need to be accessible, easily updated and graphically presented in a simple and comprehensible way (see also Chan & Chan, 2004).

Several KPIs can be found in the literature specific to different locations and for various types of projects. In a study conducted by Cox et al. (2003), the interpretation of managers at both executive and project levels in the various sectors of the construction industry led to the introduction of a variety of KPIs that were repeatedly viewed as extremely imperative for interviewees, including quality control, on-time completion, cost, safety, $/unit, and units/MHR (i.e. man-hours). Their findings indicate that different management perspectives generate significantly different KPIs, so the managers do not have the same perception of performance criteria. Hence, the above-mentioned six indicators can be used as the basis for measuring progress with supplementary indicators that complement the monitoring system dependant to the construction sector, management level and experience.

Takim & Akintola (2002) suggest that stakeholders' performance indicators could be assessed based on the three phases of the project life cycle, as shown in Table 5.

Table 5. KPIs Concerning Stakeholders' Performances (Takim & Akintola, 2002)

Client	Consultant	Contractor	Supplier	End-user	Community
PROCUREMENT STAGE - PERFORMANCE					
Client attribution	Project management capabilities	Level of experience	Quality assurance on products	Involvement in need definition	Pressures
Project attribution	Good working relationship	Financial stability & financial management			Demands
Procurement & delivery strategy	Competency		Quality control system	Contribution of ideas and requirements	Community involvement
Project viability	Consultation mode	Past performance	Product life span		Community Policy
Contractual arrangement	Commitment	Management capabilities	Replacement value	Commitment via representatives	Battleground
Briefing process	Strategic cost advise	Performance of project personnel	The concept of JIT		Closer relationship
Communication	Meeting functional requirements	Construction method and technology	Product mechanisation	Involvement in decision-making process	
Decision effectiveness	Meeting technical specification		Track record		
Risks and opportunities	Proper communication	Manpower and technical capabilities	Level of service	Joint evaluation on procurement selection	
Excessive bureaucracy	Interactive process	Project innovation	Team turnover rate		
Commitment from employees	Efficiency of approval authorities		Capabilities of key personnel		
Social obligations			Top management support		
PROJECT PHASE - PERFORMANCE					
Management structure	Team Management	Performance standard	Material Procurement	Continuous participation	Support
Project interfaces	Project interfaces	Good working relationship	Cooperation	Involvement in maintenance documentation	Cooperation
Fragmentation	Coordination	Construction method & technology	Commitment		Disruptions
Control measures	Conflicts management style	Productivity rate	Ability to deliver		Environmental effect

Client	Consultant	Contractor	Supplier	End-user	Community
Political, economic, social and legal	Communication and reporting	Safety	Product reliability		
Environment influences	Quality control system	Constructability	Delivery time		
Loyalty	Quality assurance	Communication and reporting	Contractual agreement		
Quality of work life	Dispute resolution process	Cost control mechanism	Product defects		
PHASING-OUT STAGE - EXPECTATION					
Meets pre-stated objectives	Profitability	Profitability	New market penetration on products	Meets requirements	Benefits
Meets time	Future Jobs	Achieve business purpose		Functionality	Use of it
Meets budget	Learning & growth		Future potential	Desired outcomes	Safety
Technical specification	Generated positive reputation		Exploit technology	Free from defects	Pleasant environment
Acceptable quality	Harmony	Learning and growth	Profitability	Meets quality thresholds	
Meets corporate priorities	Absence of any legal claims & proceedings	Settlements of conflicts		On-time deliveries	Public image
Harmony		Minimum risk (reduction of disputes)		Minimum cost of ownership	
Absence of any claims & proceedings	Increase the level of professional	Business relationship		Required future service	
Reduction of conflicts & disputes		New market penetration		Flexibility (for future expansion)	
Transfer of experience		Positive reputation			
Investment opportunity		New knowledge & expertise		Usable life expectancy	
Value for money				Depreciation and exploitation costs	

Ling & Peh (2005)'s study systematically develops a set of KPIs with the future intention of determining benchmarks. Table 6 indicates the KPIs and the formulas to calculate them.

Table 6. KPI Framework for Contractors in Construction Projects (Ling & Peh, 2005)

Indicators	**Formula**
COST	
Project Budget Factor	Actual Total Project Cost (Initial Predicted Project Cost + Approved Changes)
TIME	
Project Schedule Growth	Actual Total Project Duration - Initial Predicted Project Duration Initial Predicted Project Duration
Construction Time	This indicator measures the year on year change in the time to construct nominally identical projects. It shows the annual change in normalised construction time of a project from the current year to the previous year, expressed as a percentage of the time of the previous year project.
QUALITY	
Defects extent	10-point scale for client's assessment of the condition on the product/facility with respect to defects at the time of handover 1 2 3 4 5 6 7 8 9 10 1= totally defective; 5= some defects with some impact on clients; 10= defect free.
WASTE MANAGEMENT	
Waste generated	Waste generated (m3) per month
CLIENT SATISFACTION	
Client Satisfaction – Product	10-point scale for client's assessment of his satisfaction at the time of handover 1 2 3 4 5 6 7 8 9 10 1= totally dissatisfied; 5= neither delighted nor dissatisfied; 10= totally delighted.
Client Satisfaction	Same as above
Customer Complaints	Number of complaints per project
PROFITABILITY	
Project Profitability	Project Profit x100 Finalised Contract Sum
Company Profitability	Contractor's company profit before tax and interest as a percentage of sales.
PRODUCTIVITY	
Overall Construction Effectiveness	Actual construction output for the month x 100 Planned construction output for the month. Derive an average score over the project duration.
Construction Control	Actual Total Project Cost Cost of raw materials + Cost of Work-In-Progress
SAFETY	
Recordable Incident Rate or Reportable Injury Accident Rate	Number of Recordable + Reportable Cases Total Site Work-hours
Lost Workday Case Incident Rate	Total Number of Lost Workday Cases Total Site Work-hours

In 2001, the Danish government decided to set up a benchmarking system leading to the following KPIs that were based on first definitions. Since then, Danish contractors have had to prove excellence in a variety of KPIs established by the Danish Construction Sector's Benchmark Centre (Ofori-Kuragu et al., 2016; Olsen et al., 2010):

1. Actual construction time,
2. Actual construction time in relation to planned construction time,
3. Actual construction time,
4. Remediation of defects during the first year,
5. Number of defects during in handing over,
6. Accident frequency,
7. Contribution ratio,
8. Contribution margin,
9. Contribution margin per wage crowns,
10. Work intensity,
11. Labour productivity,
12. Changes in project price during the construction,
13. Square metre price, and
14. Customer satisfaction with the construction process.

For a large-scale construction project in Thailand, Toor & Ogunlana (2010) explore the interpretation of KPIs. The respondents propose time, cost and efficient use of resources as well as safety and quality as the leading KPIs. Radujković et al. (2010) argue that KPIs are always evolving as tools for performance measurement. In the future, a performance management model should be developed systematically using KPI-based benchmarking, and incorporating the recent findings into an internal performance system. They explore more than 30 construction companies in Southeast Europe and show a significant gap in the interpretation of KPIs by investors, consultants and contractors, leading to a compiled list of KPIs as shown in Table 7.

Table 7. The Top Ten KPIs Regarding Different Project Participants (Radujković et al., 2010)

N	Investors	Contractors	Consultants
1	Client satisfaction	Quality	Changes in owner's project support
2	Cost	Cost	Number of investor interferences
3	Communication (organisational)	Identification of client's interest	Cost
4	Time/schedule increase	Time/schedule	Employees' satisfaction
5	Time/schedule predictability	Cooperation with subcontractors	Profitability
6	Defects	Motivation	The satisfaction of the project team
7	Avoidance of unprofitable processes	Productivity	Cost predictability
8	Quality	Innovation and learning	Changes in project objectives
9	Rework	Time/schedule increase	Motivation
10	Legal problems with land	Client satisfaction	Cost increase

Al Hasani (2018) investigates the performance indicators suggested and utilised by different researchers around the world prior to 2016. These indicators are listed according to author and country (see Table 8).

Table 8. Identified Major Performance Indicators in Different Countries (Al Hasani, 2018)

No.	Author (Year)	Country	Performance Indicators
1	Jastaniah (1997)	Saudi Arabia	Client satisfaction Planning period Staff experience Communication Safety Closeness to budget Profitability Payment Claims
2	Construction Task Force (1998)	UK	Predictability – time, cost Construction cost Construction time Productivity Profitability Safety Defects Client satisfaction
3	The KPI Working Group (2000)	UK	Time Cost Quality Client satisfaction Client changes Business performance Health and safety

No.	Author (Year)	Country	Performance Indicators
4	Pillai et al. (2002)	India	Benefit Risk management Project status Decision effectiveness Production Cost effectiveness Customer commitment Stakeholders Project management
5	El-Mashaleh et al. (2007)	US	Schedule performance Cost performance Client satisfaction Safety Profitability
6	Alarcón et al. (2001); Ramirez et al. (2004)	Chile	Safety Productivity Quality Efficiency of labor Rework Training Planning effectiveness Cost variation Schedule variation
7	Cheung et al. (2003)	China	People Cost Time Quality Safety Client satisfaction Communication Environment
8	Wong (2004)	UK	Staff experience Resources Site management Safety Contractor experience Time Cost Quality
9	Yu et al. (2007)	Korea	Profitability Growth Stability Customer satisfaction Market share Development Technological capability Business efficiency Informatisation Organisation competency

No.	Author (Year)	Country	Performance Indicators
10	Nudurupati et al. (2007)	UK	Quality Clients satisfaction Employee satisfaction Environment impact Safety Time Cost
11	Rankin et al. (2008)	Canada	Cost Time Quality Safety Scope Innovation Sustainability Client satisfaction
12	Luu et al. (2008)	Vietnam	Construction cost Construction time Customer satisfaction Quality management Team performance Change management Material management Safety
13	Skibniewski & Ghosh (2009)	US	Construction cost Construction time Predictability cost and time Defects Client satisfaction product
14	Toor & Ogunlana (2010)	Thailand	On time Under budget Specifications Efficiency Effectiveness Safety Defects Stakeholders Disputes
15	Wang et al. (2010)	US	Profitability Return on capital Cash flow Reliability Customer focus Market share Quality Internal business Innovation and learning Environment

No.	Author (Year)	Country	Performance Indicators
16	Horta et al. (2010)	Portugal	Productivity Profitability Growth Safety Customer satisfaction Predictability
17	Construction Industry Institute (2011)	US	Cost Schedule Changes Accident Rework Productivity
18	Meng, X. (2012)	UK	Trust No-blame culture Communication Problem-solving Risk allocation Performance measurement
19	AL Mousli et al. (2016); Al-Hajj & Sayers (2014)	UAE	Cost and schedule Poorly written contracts Objective Knowledge and experiences Quality Communication

Overall, the literature still lacks a set of generic KPIs that can be employed in the evaluation of all types of projects. However, as cost, time, scope and risk are generic for all projects, a set of KPIs formulated on these success factors seems possible.

2.4 PROJECT SUCCESS MODELS

In this section, project success models proposed over the last 30 years are analysed. This extensive review enables the study to identify and understand the shortcomings in the knowledge area and support the basis for a model for measuring project delivery success.

2.4.1 NICHOLAS (1989)

The first one is a model developed by Nicholas (1989) that comprises major project management causes of success that are identified from a survey and organised as shown in Figure 2. The model categorises success drivers into three classifications: project participants, communication and information sharing and exchange, as well as the development of project management systems.

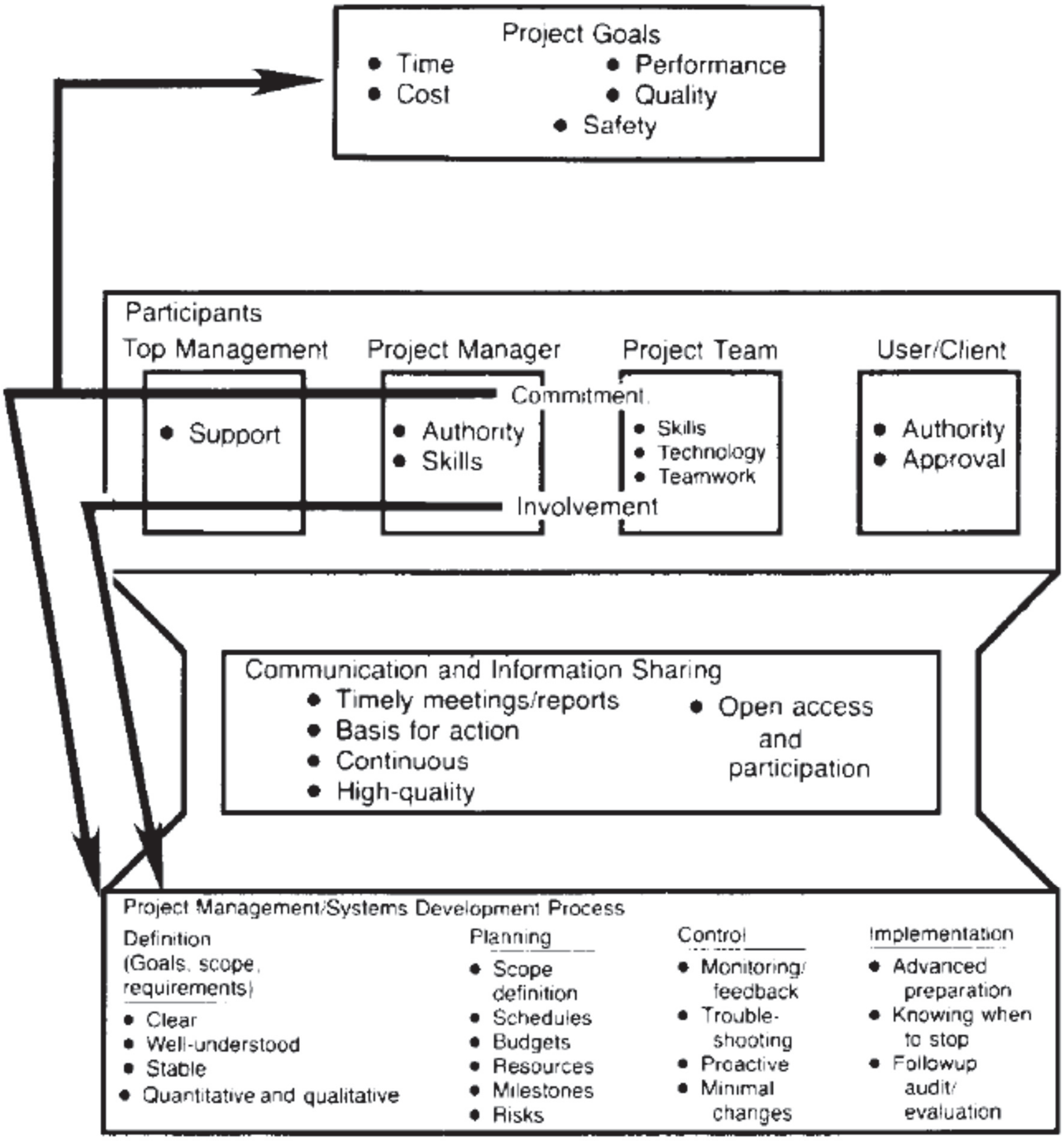


Figure 2. Project-Management Causes of Project Success (Nicholas, 1989)

Project Participants:

The strong commitment of the people involved with the projects is clearly recommended by Nicholas (1989) in the first section of this model. This dedication should be retained across all participants throughout multiple project divisions and phases such as planning and execution in the accomplishment of goals and objectives. Participants must, therefore, recognise the value of project management procedures, apply the related methods and use the tools and techniques needed to carry out the related tasks to fulfil project objectives. Additionally, involvement in project processes is necessary, and participants must engage in the procedures where initiatives or certain inputs are needed. It could provide the project team with great support in resolving the issues and addressing important risks. The participants and the level of commitment and involvement they need to consider are as follows:

1. *Top Management:* Senior management support for successful projects is crucial since it influences the degree to which the plan is embraced or refused. Project managers need extensive managerial support in especially in dealing with major challenges where proper resource utilisation and project personnel leadership is required. Such support becomes more vital in times of crisis when a critical decision needs to be taken immediately, and project managers must feel confident in implementing the best possible decision without stressing about the possible consequences (obviously after reviewing all the detrimental and beneficial impacts of that decision). At that time, Nicholas (1989) mentions that someone above the project manager would have been designated to communicate with all the key players. The project manager would bring the issues to this individual to solve the problem and plan for potential risks.
2. *Project Manager:* The project managers are committed to meeting time, cost safety and quality targets in successful projects. They engage deeply in the project from start to finish, and they are given adequate power to control the development of plans and strategies, make improvements and changes.
3. *Project Team:* as part of the team-building process to improve trust among team members, they should be actively involved key project processes, such as estimating,

decision-making, planning, risk mitigation, scheduling, monitoring and controlling. In a successful project, creating such an environment where close teamwork and a strong commitment to project objectives are of high importance, team members would be highly motivated and maintain excellent productivity continuously under an influential leadership that delegates authority where possible.

4. *Users:* Nicholas (1989) argues that who the client is would not be questioned in a successful project. The end-user would be identified before the start of the project, and their requirements would have to be encountered before the beginning of the planning process. The client may be involved in various key procedures, such as the subcontractor evaluation process, making important decisions, and approving or refusing changes, and should be fully committed to the goals of the project. Although the expectations of the client have been gathered and addressed in the plan, they must be engaged in the process at different stages of the project, as further clarity of the specifics may be needed so that the project team are able to set clear goals and acceptable criteria for evaluating the success of these objectives.
5. *Communication and Information Sharing and Exchange:* Good communication and high-quality information sharing and exchange take place in successful projects. Effective communication ensures that project stakeholders can be connected easily, and project management and system development processes are facilitated. For successful projects, team members are in constant and direct contact. Good coordination is preserved throughout all project phases, from concept to delivery. Proper scheduling and monitoring results in good communication that also rely on the quality and quantity of face-to-face meetings. There are frequent regular meetings in successful projects to exchange information, data and suggestions on project targets, status, strategies and changes. At meetings, the priority unit is defined and the leading roles are adjusted as required. Personnel are dedicated to fixing and resolving issues efficiently. An effective approach to improve the participants' awareness of the project goals and other

stakeholders' roles at various stages of the project is to hold 'teach-in' meetings that can be undertaken in a friendly environment where shared trust is high.

Project Management and Systems Development:

In this study, Nicholas (1989) identifies a number of factors relating to project definition, planning, control and implementation that may contribute to achieving successful outcomes and categorises them as project management functions or elements of the systems development process, as follows:

1. *Definition:* The goals and objectives of the project are clearly defined and recognised in successful projects, and the participants have a high awareness of the processes and tasks to be carried out in order to fulfil the requirements of the client. As mentioned earlier, some changes and adjustments to the requirements and objectives might occur during the project through a robust change management procedure. However, a continuous change in scope generates complex risks that could reduce the possibility of success. The project team should attempt to quantify the requirements and set tangible objectives that allow performance measurement to run much faster while, inevitably, there are still some intangible expectations that should be constantly taken care of by the team.
2. *Planning:* Proper planning and scheduling are important elements for project success accompanied by the implementation of the plan with an effective monitoring system. An efficient strategy relating to time, funding and quality is essential for successful projects. A good project plan appropriately includes reasonable cost estimates, planning and network techniques, milestones, definition of scope and activities, an analysis of the cash flow, labour and equipment demands, and risk analysis. It ensures the tough things are done first (the things people like to refrain from thinking about). For successful projects, safety is also of major concern. Plans include safety requirements and monitoring and safety measures for participants.

3. *Control:* Similar to the planning phase, a robust monitoring and controlling system should be implemented in the project and must be able to detect even small scope creep and deviations from the plan. This system must continuously compare the actual cost and time performance to the schedule. All information should be communicated efficiently in a meaningful way at the right time, so the project manager or team can take corrective actions immediately. This procedure should be proactive to allow adequate time for the team to make a relevant decision and avoid further damages. Milestones can be utilised in larger projects to continuously monitor the goals and resolve the issue arise in a timely manner to ensure the outcomes will be successfully achieved.
4. *Implementation:* Effective planning for implementation is also essential for successful projects. In the initial plan and throughout the project, implementation should be addressed. The project team and the user have a strong relationship with each other on the scheduling and execution details. Plans may shift away from prior targets or even go beyond objectives, and the tendency is to do too much and continue for too long. The approved plan clearly explains when and how the project should be terminated in successful projects. There is a possibility that the project might continue further than necessary without clear termination criteria.

2.4.2 BELASSI & TUKEL (1996)

Belassi & Tukel (1996) claim that their framework, shown in Figure 3, would address many of the gaps in the literature. They group the criteria for project success into four areas:

- factors related to the project,
- factors related to the project manager and the team members,
- factors related to the organisation, and
- factors related to the external environment.

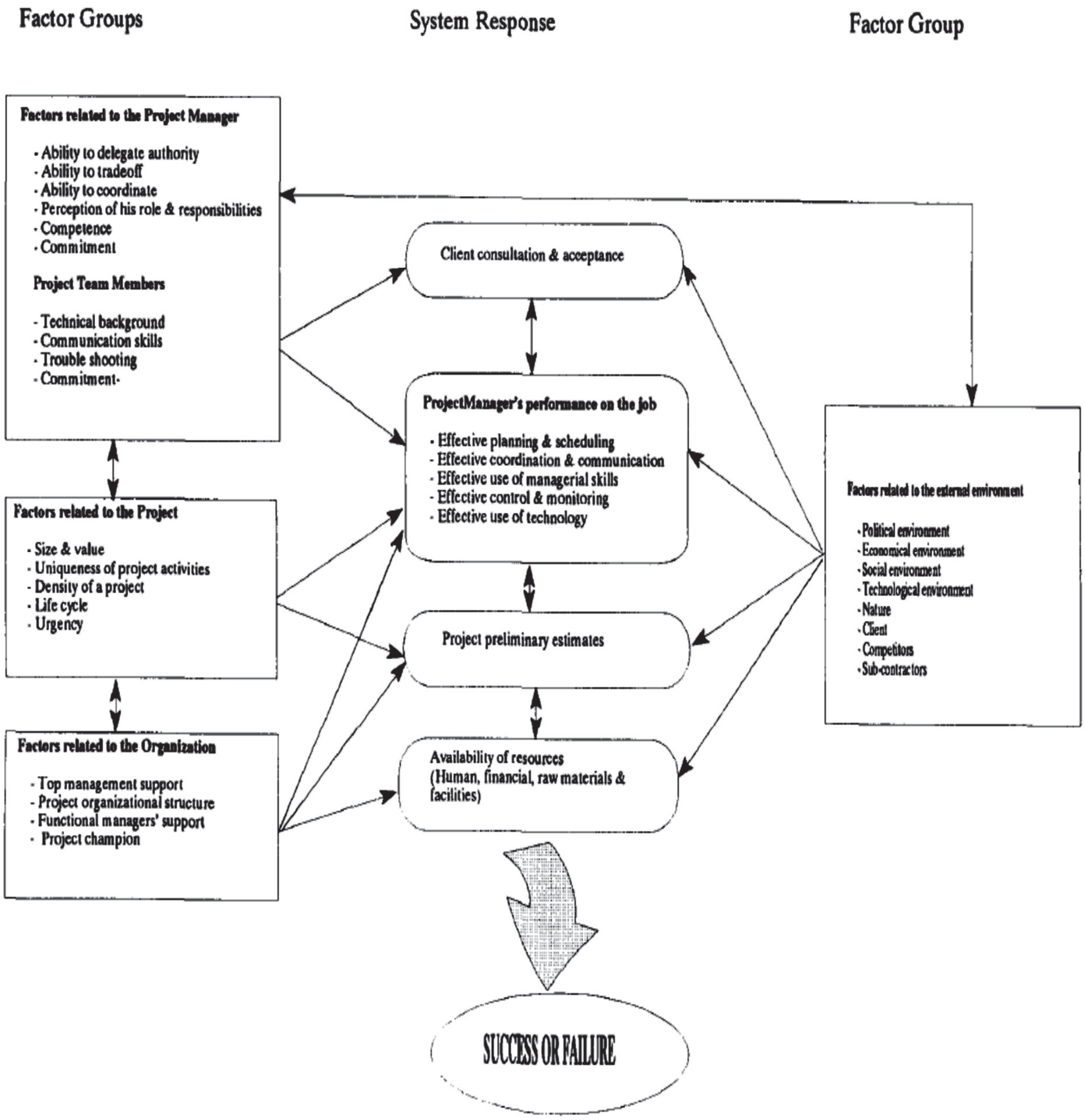


Figure 3. Project Success Framework (Belassi & Tukel, 1996)

The established dimensions are highly interconnected, meaning a single factor of one aspect can affect the factors in other sections or even affect the project results leading to overall failure or success. For example, ‘competency’ as a crucial factor in the project manager group can affect the ‘effective use of managerial skills’ in the project manager’s performance group. This type of categorisation of factors might be helpful in finding the root causes of defects, deficiencies or overall failure. Likewise, this can help project managers to understand the interrelationships among the main dimensions of project success. For example, resources are known to be a foundational element for the successful completion of projects in the literature. Nonetheless, Belassi & Tukel (1996) say that resource supply is a system reaction to variables such as top management support for operational, environmental and project management, the negotiation skills of project managers and the general economic condition. It allows project managers to more reliably assess and track their tasks. However, several intangible and qualitative factors in the model such as 'ability to delegate authority' are hard to be measured so that it might be unclear to what extent such factors can influence the likelihood of success.

Belassi & Tukel (1996) set comprehensive criteria that comprise almost all other factors in the literature as of 1996. They argue that by using this framework, project managers can easily observe these cause and effect relationships. Furthermore, they can easily adapt this framework to their specific situations and include the factors that were found to be critical for their project's success.

2.4.3 LIM & MOHAMED (1999)

Another model created by Lim & Mohamed (1999) comprise three stages. First, there are building blocks (see Figure 4) that form the entire life cycle of a project from concept design to the operation stage where the project is handed over, the product is ready to use, and it is operational.

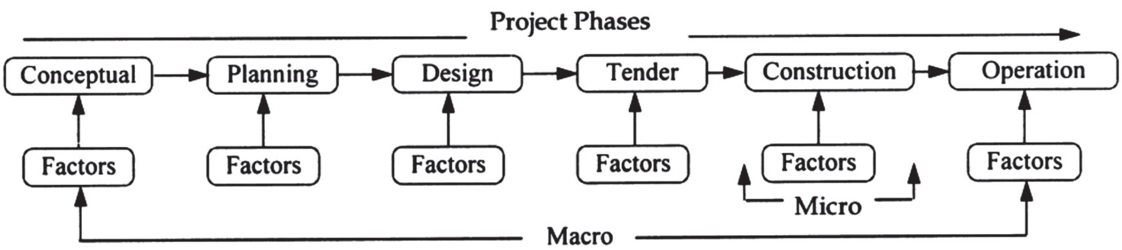


Figure 4. Building Blocks of the Project Life Cycle (Lim & Mohamed, 1999)

There are several factors that can affect the processes and ultimately the outcomes. They make examples of these factors, including '*feasibility studies, marketing research, data of various kind, experience, site conditions, weather, flood, shortages, wastage, mistakes, workmanship, damages, thefts, approvals, changes, supervision, logistics, interfacing, and so on*' (Lim & Mohamed, 1999, p.245).

The second part of the model (see Figure 5) relates to the macro view of project success, comprising the two main project stages of conceptual phase and operational phase. The former includes the initiative and the need to make a change and to undertake a project, while the latter deals with testing what is built and delivered to see whether it meets all the requirements and possesses the functionality promised. Therefore, the key stakeholders include the client, customer, sponsor, owner, community, end-user, etc. In order to measure how successful, the project is from the macro viewpoint, surveys focusing on satisfaction and completion criteria would be beneficial. The model depicts completion as the first success criteria with time as the main factor along with other factors such as management, supervision, economy, weather, etc. For example, the corporate tenants may wish to move in and start a business for a certain period, or the road users may want to reduce road blocks, traffic jams, accidents, etc.

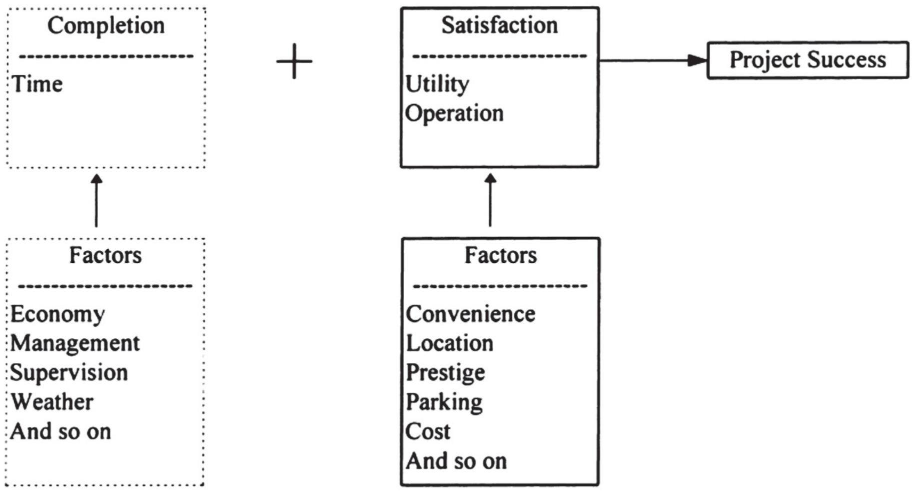


Figure 5. Macro Viewpoint of Project Success (Lim & Mohamed, 1999)

By setting satisfaction as the second success criteria, the product or deliverables need to be tested to see how well they satisfied the stakeholders mentioned above, so the overall success here is highly dependant on the user experience of the final product. So many factors could affect the satisfaction level, such as convenience, location, prestige and the like. In most cases, when the final product is desirable in the end user's opinion, then the deficiencies and deviations from the promised plan become less important and more forgivable. One good example mentioned before is the Sydney Opera House, that was completed massively over budget and much later than expected; however, it is now respected as the iconic symbol of Sydney and a modern wonder of the world. The intangible force of satisfaction is so immense that any shortcomings in the project management of this building are ignored. This can be seen in the model where dotted lines have been used to indicate that the completion criteria, in exceptional circumstances, can be disregarded.

The micro viewpoint determines the overall success of the project. However, these criteria are being affected by the factors of the micro viewpoint of project success (see Figure 6).

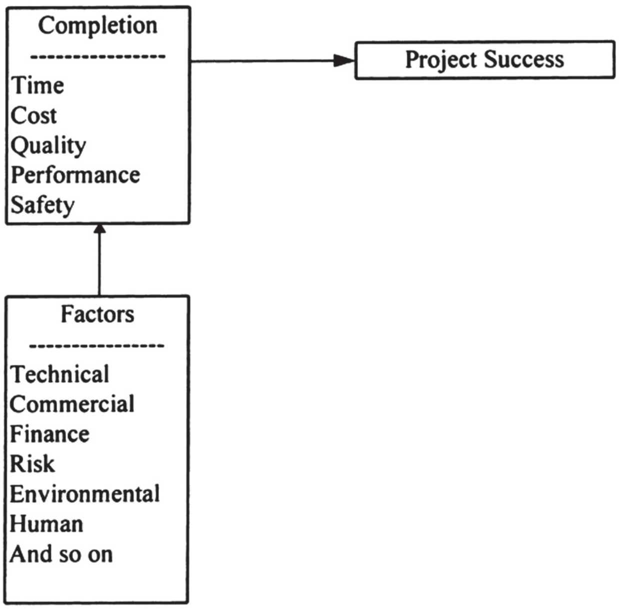


Figure 6. Micro viewpoint of Project Success (Lim & Mohamed, 1999)

Similar to the macro viewpoint, this area is also related to some of the project's key stakeholders, namely the developer (in the project phase) and the contractors. The execution or construction phase forms this viewpoint and the main success criteria identified by the previous researchers such as budget, time, quality, safety, etc. appear under this part of the model. Therefore, the performance of the project manager/team, the processes involved and the tool and techniques employed determine the success at this stage. This is the phase where, mostly, construction happens, and the developers who have previously set the traditional criteria of time, cost, quality, etc. measure the project success and will consider it successful if it meets these criteria no matter how desirable the final product is to the end-users.

The literature before 1999, when this model was proposed, has shaped the completion criteria. Those include a wide range of criteria stemming from different factors such as technological, economic, political, organisational, risk, human, etc.

Lim & Mohamed (1999) state that it is important to keep in mind that any sector has its own specific set of factors, so any model developed to measure project success is required to be customisable to the organisation's criteria or should use generic performance measures applicable to all type of projects. A further point to consider is that the set of completion criteria for the micro viewpoint is probably not the same as those for the macro viewpoint. The corresponding sets of variables are also unique in their contents.

2.4.4 TURNER (1999)

Turner (1999) recasts and develops a model that Morris & Hough (1987) had created after reviewing seven major successful and unsuccessful projects in the UK from three consecutive decades starting in the 1960s. Turner (1999) named it the seven forces model for project success (see Figure 7) that includes five success factors in each area:

1. *Context:* the political, economic, social, technical, legal and environmental influences of and on the parties involved,

2. *Sponsorship:* the finance provided by the owner, the benefit expected in return, and the time scale which makes that benefit worthwhile, and will repay the finance,
3. *Attitude:* representing the importance attached to the project and the support given from all strata of management, from the leaders to the followers,
4. *Definition:* what the project is required to do, the approach to its design and technology expected to deliver it,
5. *People:* their management, leadership, teamwork and industrial relations,
6. *Systems:* for planning, reporting and control, by which progress will be measured and managed, and
7. *Organisation:* the roles, responsibilities and contractual relationships between the parties involved.

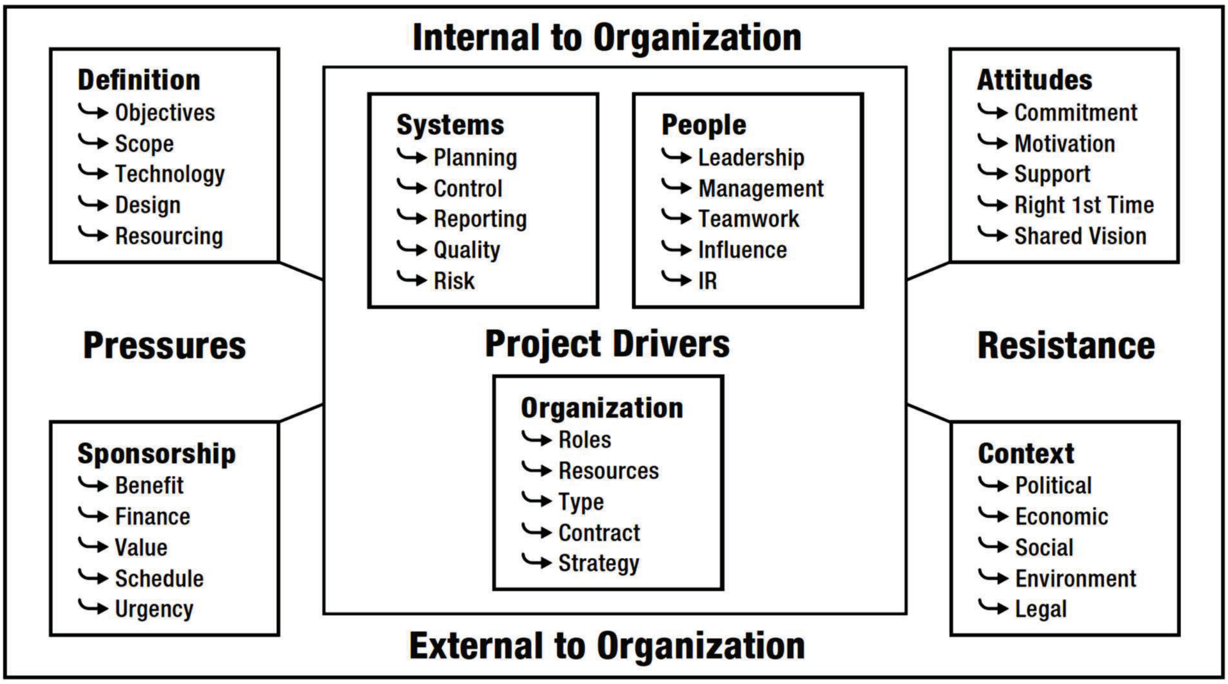


Figure 7. The Seven Forces Model for Project Success (Turner, 1999)

2.4.5 CHAN ET AL. (2002)

Chan et al. (2002) develop a framework with particular focus on design-build projects (see Figure 8) that was in turn based on the findings of Shenhar et al. (1997) who believed that project success criteria change over time.

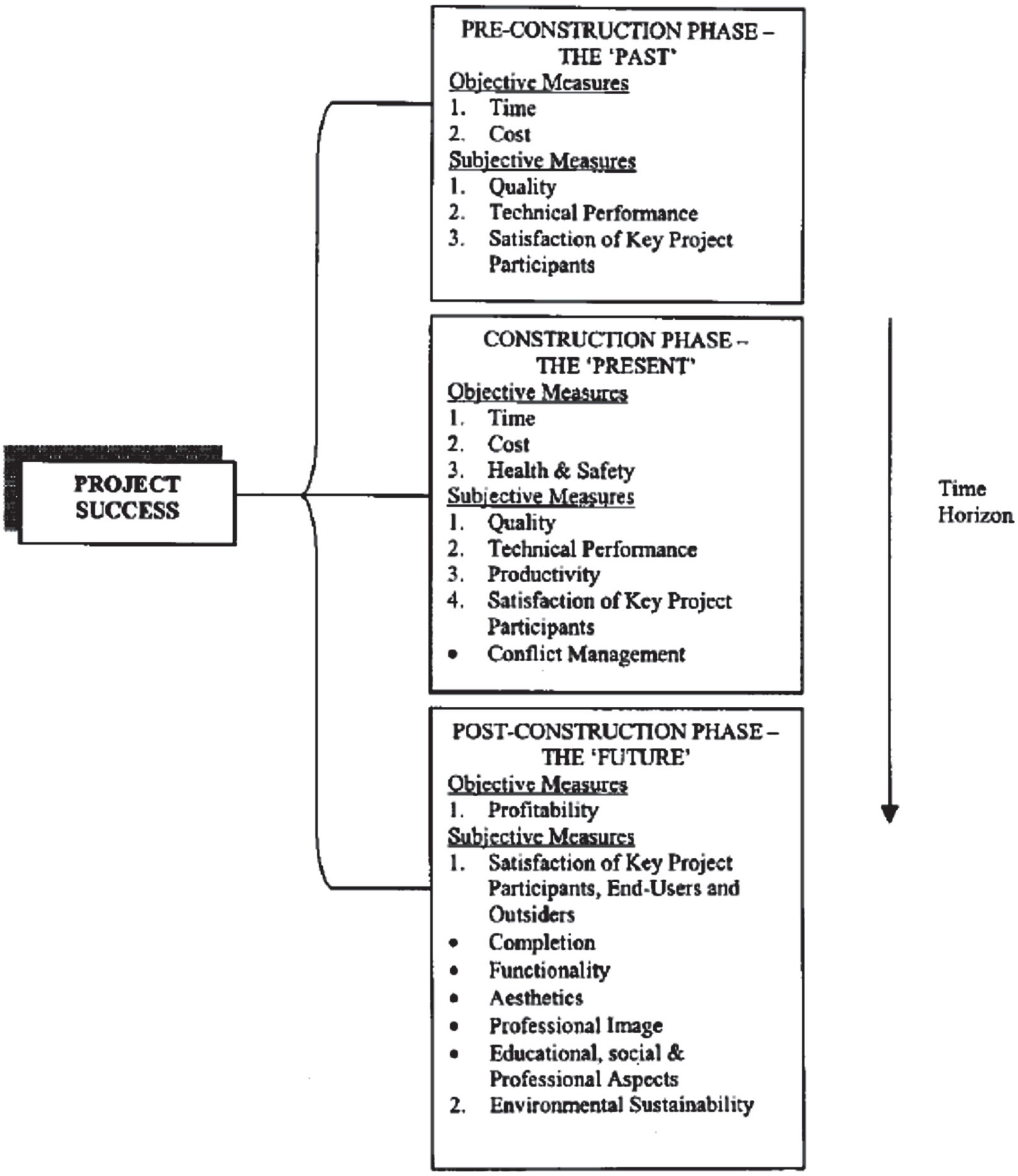


Figure 8. Assessment Framework for Project Success (Chan et al., 2002)

They review the relevant literature looking for the generic success criteria and attempt to customise them to design-build projects. This framework measures project success at three consecutive stages of pre-construction, construction, and post-construction (Morris & Hough, 1987), and comprises both objective and subjective measures.

The objective measures are:

- *Time:* defined as the degree to which the general conditions promote the completion of a project within the allocated duration,
- *Cost:* defined as the degree to which the general conditions promote the completion of a project within the estimated budget,
- *Health and Safety:* defined as the degree to which the general conditions promote the completion of a project without major accidents or injuries, and
- *Profitability:* measures the financial success of the project.

The subjective measures are:

- *Quality:* defined as the degree to which the general conditions promote the meeting of the project's established requirements of materials and workmanship,
- *Technical Performance:* the level of clarity in the project's scope definition/specification,
- *Functionality:* the expectations of project participants that can best be measured by the degree of conformance to all technical performance specifications,
- *Productivity:* the amount of resource input to complete a given task and it is usually assessed on a ranked basis,
- *Satisfaction:* the level of ''happiness'' of people affected by a project, including key project participants: namely the client, architect, contractor, various subcontractors, surveyors and engineers, end-users, and third parties,
- *Environmental Sustainability:* the level of the environmental impacts of a construction project.

2.4.6 WESTERVELD (2003)

Westerveld (2003) introduces 'The Project Excellence Model' (see Figure 9), which is created based on the European Foundation for Quality Management (EFQM) model. This framework links project success criteria and critical success factors into one logical model. In 1989, fourteen multinationals participating in the European Foundation of Quality Management created the EFQM business excellence model to strengthen management performance in Western Europe. The EFQM model has been used to evaluate and optimise an organisation's overall quality. The methodology embraced by the EFQM is distinct from many methods employed in the area of project management. Westerveld (2003) states that such difference comes from unclear links between the discipline's knowledge areas, as articulated in the *PMBOK® Guide* (PMI, 2017). But a clear relationship could not have been seen, at least in the edition that was published at the time. Additionally, as the EFQM model has been developed for ongoing business practices, it cannot be easily applied to projects that possess unique goals and are temporary.

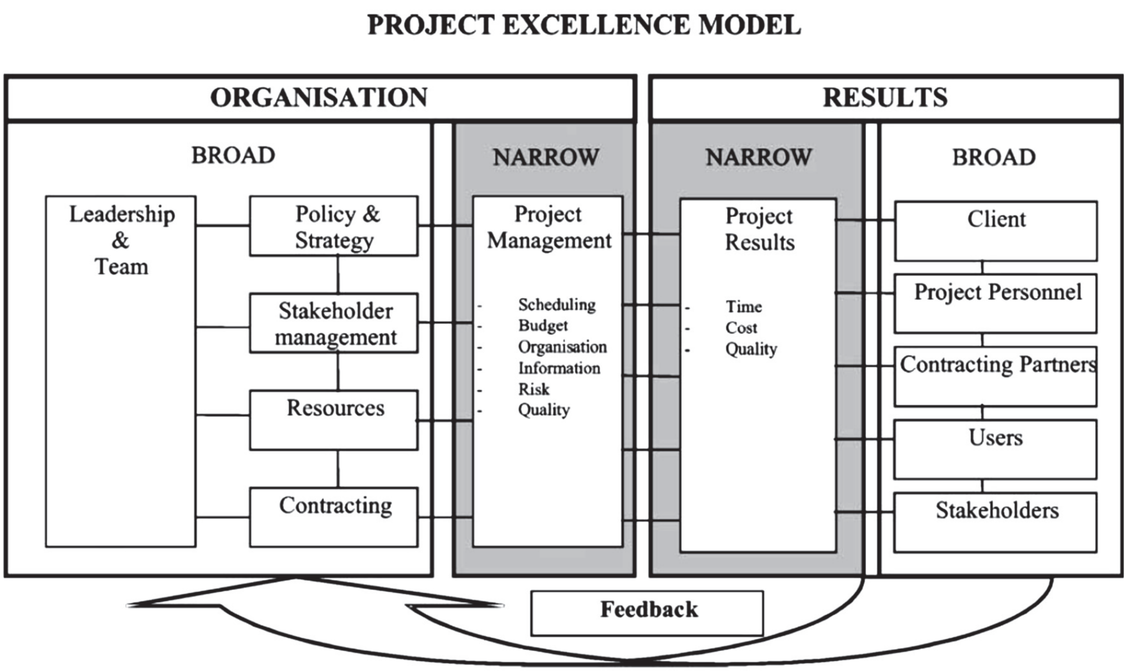


Figure 9. The Project Excellence Model (Westerveld, 2003)

This model is developed based on the difference between two main areas of success in projects. This is similar to what the literature suggests before. As projects can be viewed the same as organisations, the model considers the results of both areas, so if managers aim to increase the likelihood of success they need to focus on these:

1. *Result Areas:* project success criteria
2. *Organisational Areas:* critical success factors

Westerveld (2003, p.417) claims that the model can be applied to any type of project in various situations to evaluate performance:

> *At the project start-up (PSU) the project organisation and its stakeholders decide on the project goals. These goals can be categorised using the six result areas of the Project Excellence Model. Then the basic choices in the project organisation have to be made using the five project types on each of the six organisational areas. After the project start-up, the Project Excellence Model can be used to monitor the results and the project organisation. Based on this analysis, the functioning of the project organisation can be improved if needed. Eventually, the model can be used to analyse and transfer learning experiences to future projects.*

2.4.7 FRASER & TURNER (2002)

The model that Fraser & Turner (2002) propose (see Figure 10) seems slightly different from the preceding ones. Their research discusses the skewing capacity associated with project assessment and aims to reflect internal, external and meta-level domains where there can be inconsistencies between actual and recorded project outcomes. The models that have already been reviewed in this study focused on project success as the final output, while this model focuses mainly on the identification of components that could potentially influence the reporting of project success. However, the different areas of the model, including the success of the project, are not time-linear or dependent, and would likely affect the reported success of the project in different ways and will have diverse weighted impacts.

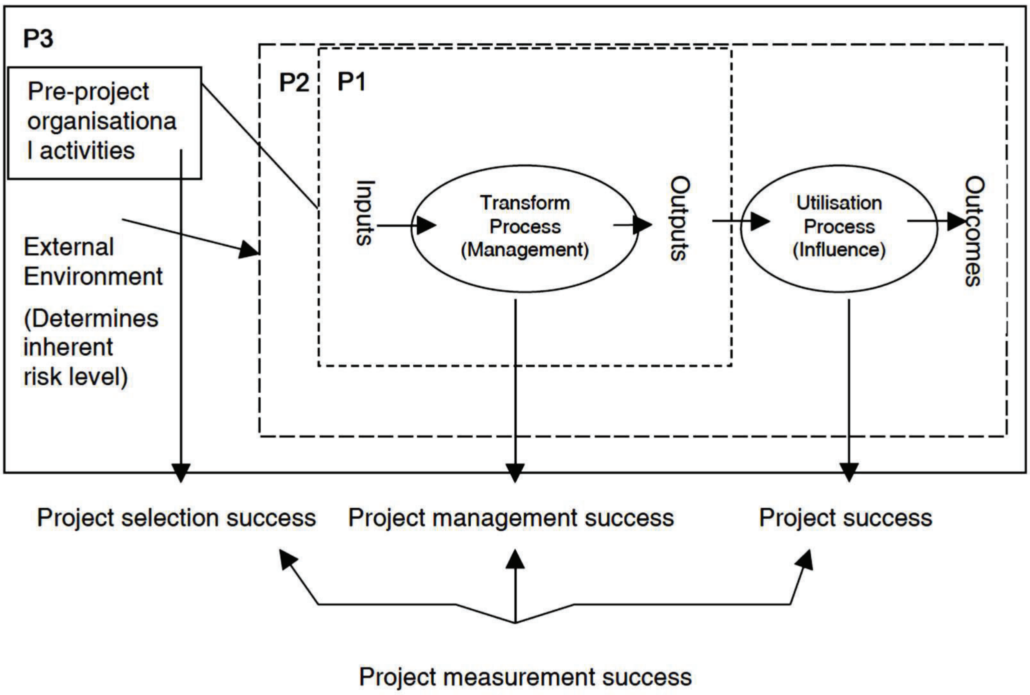


Figure 10. Determinants of Reported Project Success (Fraser & Turner, 2002)

Fraser & Turner (2002, p.18) report that the main influences upon reported project success identified in this model are:

- *Project selection success – Did the organisation choose the right project to undertake at the right time and set the project up in the right way? If not, how should overall success measures be adjusted to reflect this?*
- *Project management success – Were the project management processes performed successfully? This was measured against the widespread and traditional measures of performance against time, cost and quality.*
- *Project success – Did the project achieve its critical success factors and to what level? This was measured against the overall stated objectives of the project.*
- *Project measurement success – How accurately did the assessment of project success reflect the actual level of project success relevant to the project? What was reported as project success – PM success, project success, or an aggregate? Were weightings used and if so, how? What stakeholders' perspective(s) were measured? Over what time*

period(s) were the success measures undertaken? Did the measures take into account the level of project selection success and criteria relative to that?

Within this framework, most project success is a combination of project management success and successful output design including the strategies for utilisation (Fraser & Turner, 2002). They believe that their model can be beneficial in situations where the accuracy of reported project success and previous studies on project success are the subject of investigation.

2.4.8 KENDRA & TAPLIN (2004)

Kendra & Taplin (2004) introduce a framework (see Figure 11) that seems unique and revolutionary at the time. It is designed to help information technology (IT) companies develop their existing project management practices and efficiency, which they believe would contribute to more successful projects. This framework facilitates IT organisations to systematically evaluate their current project management maturity and capabilities and to identify primary deficiencies within their management system, and therefore to find suitable approaches and take corrective action to effectively improve the performance of their projects and increase the likelihood of success.

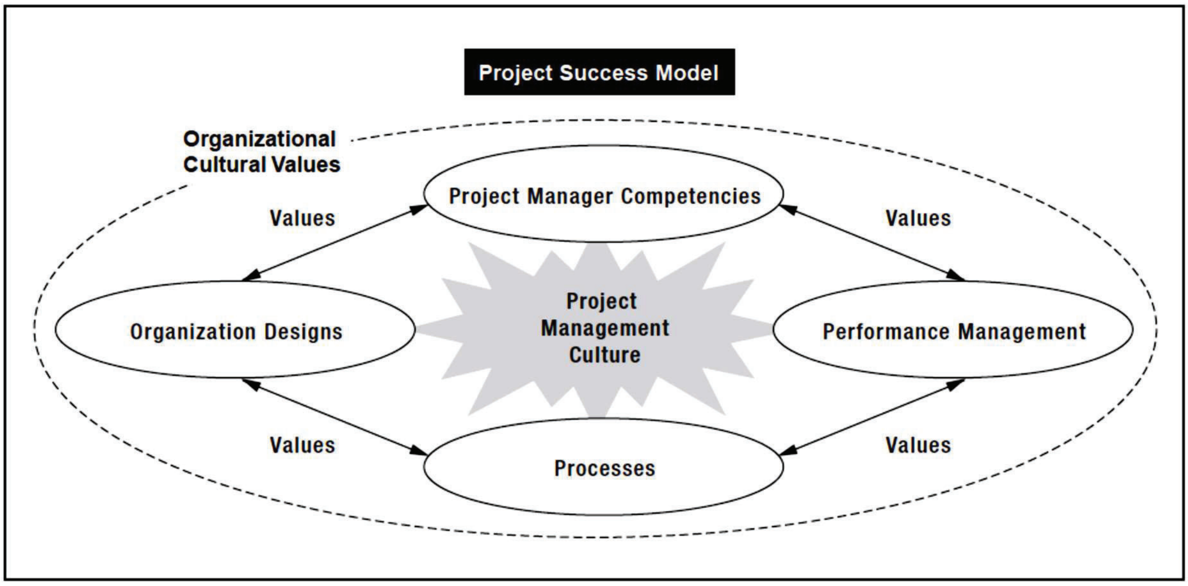


Figure 11. The Project Success Open System Cultural Model (Kendra & Taplin, 2004)

This model has been built upon the so-called four dimensions of project success, concluded from the literature. These dimensions include the competencies of project managers, performance measurement systems, business processes and project organisation structures. To identify and develop these success dimensions, the CSFs identified in the literature have been categorised into a 2x2 matrix consisting of macro and micro levels of social and technical organisational design concepts. The social aspect refers to the project participants who work directly on the project processes such as the project team and the project manager. The two dimensions of project manager competencies and project organisation structures fall under this group. The technical aspect refers to the activities and processes undertaken by people outside the project but within the organisation that support the project in various ways. The performance measurement system is a success dimension at the micro level and business processes is a dimension at the macro level.

This evaluation procedure assesses the competence of the project managers within the organisation, defines the business processes that support the business model, describes how resources (structure) are assigned to projects as well as the criteria of project success that support the project management performance evaluation system. Additionally, it helps companies determine the culture of a project and develop action plans to focus on strengthening project management efficiency in the areas of project management capabilities, performance measurement systems, business procedures support and project structures.

2.4.9 SHENHAR & DVIR (2007)

A project success model proposed by Shenhar & Dvir (2007) is in the form of a collection of project success criteria classified into five categories: efficiency, impact on the team, impact on the customer, business success, and preparing for the future. This model (see Table 9) compares the people who are concerned with the macro-level of the Lim & Mohamed (1999) model, where the owner, users, consumers, sponsor and investor form one group named as the customer. However, Shenhar & Dvir (2007) argue that factors related to the organisational success such as business development and future work due to brand recognition and improved reputation are mainly the investor/sponsor or owner's concern. Success criteria in this framework appear in a time-related fashion. This implies that those on the left can be determined after completion of the project, the middle criteria can be assessed in a relatively short period of time after the end of the project, and those on the right are long-term success criteria.

Table 9. Model of Project Success (Shenhar & Dvir, 2007)

Efficiency	**Impact on Team**	**Impact on Customer**	**Business Success**	**Preparation for the Future**
Meeting schedule	Team satisfaction	Meeting requirements	Sales	New technology
Meeting cost	Team morale	Meeting specification	Profits	New market
Yield, performance, functionality	Skill	Benefit to the customer	Market share	Yield, performance, functionality
Other defined efficiencies	Team member growth	Extent of use	ROI, ROE	New core competency
	Team member retention	Customer satisfaction	Cash flow	New organisational capability
	No burnout	Customer loyalty	Service quality	
		Brand name recognition	Cycle time	
			Organisational measures	
			Regulatory approval	

2.4.10 BANNERMAN (2008)

Bannerman (2008) reviews the past literature on project success and attempts to define it in an alternative way via developing a framework. His definition is based on the fact that he proposed before, implying no matter how the project is performing at lower levels, project success is the highest level reached, at any stage of evaluation. This model measures success at different levels of the project (see Figure 12) where milestones have been met, including the stages after project closure to capture the opinions of various stakeholders.

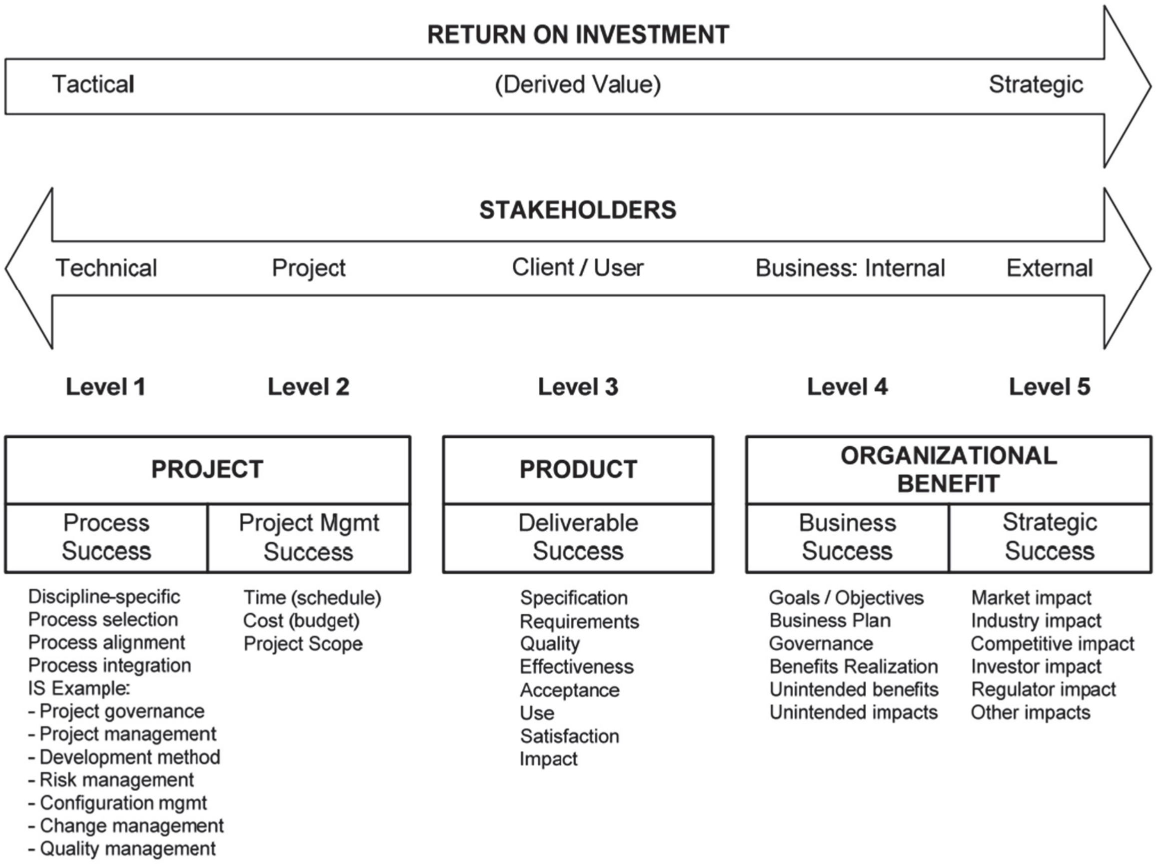


Figure 12. Five Levels of Project Success (Bannerman, 2008)

Bannerman (2008, p.6) states that '*key milestones in this spectrum relate to the project itself (the processes used and their effectiveness in delivering the project within the major design constraints), the product or main deliverable produced by the project (it is fit to specifications and purpose as well as acceptance and use), and the organisational benefits returned from the investment (achievement of business objectives and the generation of strategic value*'.

These milestones, as shown in Table 10, mark the five stages at which project performance can be officially or casually evaluated. There are different criteria set to measure the performance at these levels: for instance, the criteria for level 2 to 4 are what most researchers in past studies have proposed. The criteria in level 5 can be found in the literature but have not been grouped in an explicit way before. However, the criterion in level 1 include different factors to the common project management success models as it mainly focuses on the technological aspect of the projects, especially in information systems projects, and it supports learning and development in project application domain in the design and execution of such projects.

Table 10. A Multilevel Framework of Project Success (Bannerman, 2008)

Level	Success Criterion	Description	Empirical Indicators
1	Process	Discipline-specific technical and managerial processes, methods, tools, and techniques employed to achieve the project objectives.	Technical and managerial processes were: Appropriately chosen for the purpose Aligned with the project objectives Integrated with each other (as appropriate) Effectively implemented
2	Project Management	The project design parameters or objectives. Here 'scope' refers to the intended scope of the project (e.g., to specify, build, test, and implement a new system), not the scope of specifications of the main project deliverable.	Schedule met Budget not exceeded Project scope achieved
3	Product	The main deliverable(s) from the project. The nature of the deliverable(s) will be discipline-specific. For example, it might be a product, system, building, bridge, airplane, rocket, or a service of some kind.	Specifications met Requirements met Client/user expectations met Client/user acceptance Product/system used Client/user satisfied Client/user benefits realised
4	Business	The business objectives that motivated the investment. That is, what the business wanted to achieve from the investment.	Objectives met Business case validated Business benefits realised
5	Strategic	Business expansion or other strategic advantage gained from the project investment, either sought or emergent.	Business development enabled External stakeholder/competitor recognition Competitive response generated

A brief description of success at each level follows:

- *Level 1 – Process success:* The assessment of performance at this stage considers the suitability of the methods used, their compliance with the purpose of the project and their implementation and their efficiency in improving the project outcomes.

- *Level 2 – Project management success:* The traditional project management success criteria such as budget, schedule, quality/scope are used at this level meaning the actual numbers will be compared against the plan after the project closure.
- *Level 3 – Product success:* This level utilises the same approach as the previous criteria but at the product level and evaluates the final product to find out if it meets the promised requirements. Customer/client satisfaction is also assessed at this stage.
- *Level 4 – Business success:* Success at this level reflects the project's repayment of net positive contributions to the organisation. It can also include an assessment of the organisational contribution to the outcomes of the project.
- *Level 5 – Strategic success:* At this stage, external stakeholders, including investors, competitors, industry analysts and regulators, assess the organisational benefits rather than company insiders.

This approach allows for effective assessment and regular re-determination of how the plan contributes over time. It also helps participants to gradually monitor the value that the project's performance generates towards success. On this basis, the project performance is characterised at all points of analysis by the highest level of the gain obtained by the project.

2.4.11 KHANG & MOE (2008)

Figure 13 provides a full representation of the Khang & Moe (2008) framework, that integrates the criteria and factors proposed in the literature, regarding international development projects, into one system that links the phases of the project's life cycle. In order to develop this model, they create a questionnaire comprising 53 success factors and distribute it to more than 1000 project managers, as well as others involved with international development projects in Myanmar and Vietnam. Interestingly, most of the project participants display a positive judgment of success in the project they had been involved with. However, the general public as the end-users have different ideas and give significantly lower scores to those projects. They analyse the data statistically to create the framework.

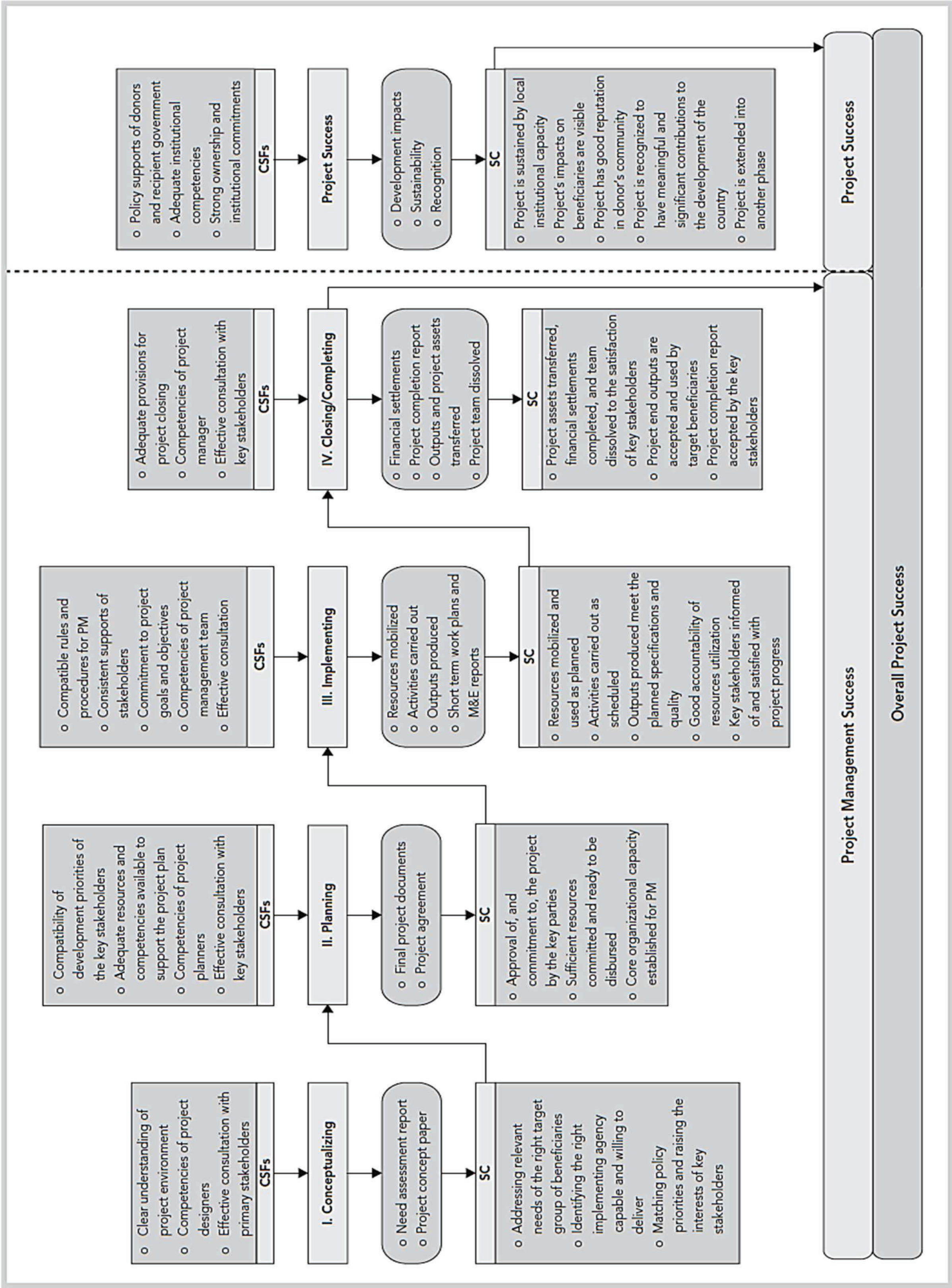


Figure 13. Project Life-Cycle-Based Framework (Khang & Moe, 2008).

Khang & Moe (2008, p.83) state that this is:

> […] *a new framework that is developed based on the previous empirical and conceptual research on critical success factors of projects and adapted with special consideration on the characteristics and context of the international development projects. The key distinction here is the recognition of the different sets of success criteria and conditions for the different stages of the project life cycle. For each phase of the project, the explicit list of the success criteria is developed based on analysis of the results typically expected at the end of the phase to provide a result-based framework to evaluate the project management performance. Meeting these success criteria requires favourable internal and external conditions that include the high-quality inputs from the preceding phase as well as other factors that are derived from an understanding of the activities required for, and the parties involved in, the phases. The dynamic linkages between the criteria and factors in successive phases provide a more solid conceptual foundation to evaluate the project's current and future status, because the different activities, players, deliverables and environments at the various project phases necessitate different conditions for success.*

They believe that, although this model is based on a survey undertaken only in two countries, it might have significant practical implications in other developing countries as it highlights the need to start the right project. This is because success in the early phases of the project may considerably affect the later stages.

2.4.12 TURNER & ZOLIN (2012)

Turner & Zolin (2012) develop a model for anticipating performance measures for managers to explore perceptions of success among stakeholders (see Table 11). They have shown that the view of success is evolving and changing. They conclude that, in order to acquire an understanding of how to deliver a successful project, the viewpoints of the various stakeholder groups have to be integrated over multiple timeframes.

Table 11. The Model for Project Success (Turner & Zolin, 2012)

Results Timescale	Project Output End of Project	Project Outcome Plus Months	Impact Plus Years
Investor or owner	Time Cost Features Performance	Performance Profit Reputation Consumer loyalty	Whole life value New technology New capability New competence New class
Project executive or project sponsor	Features Performance Time and cost	Performance Benefits Reputation Relationships Investor loyalty	Future projects New technology New capability New class
Consumers	Time Price of benefit Features	Benefit Price of product Features Developments	Competitive advantage Price of product Features Developments
Operators/users	Features Performance Documentation Training	Usability Convenience Availability Reliability Maintainability	New technology New capability New competence New class
Project manager and project team	Time Cost Performance Learning Camaraderie Retention Well-being	Reputation Relationships Repeat business	Job security Future projects New technology New competence
Senior supplier (design and/or management)	Completed work Time and cost Performance Profit from work Safety record Risk record Client appreciation	Performance Reputation Relationships Repeat business	Future business New technology New competence
Other suppliers (goods, materials, works, or services)	Time Profit Client appreciation	Reputation Relationships Repeat business	Future business New technology New competence
Public	Environmental impact	Environmental impact Social costs Social benefits	Whole life social cost-benefit ratio

In order to create this framework, they target 152 managers in large projects and find two project success factor scales including success in project planning and key participants engaged, and nine stakeholder satisfaction factor scales comprising stakeholder satisfaction, project executive satisfaction, product satisfaction, product efficiency, satisfaction with specifications, project manager satisfaction, contractor satisfaction, supplier profitability, public stakeholder satisfaction.

2.4.13 SUDHAKAR (2012)

Sudhakar (2012) investigates software development projects and the previous studies conducted in the literature related to their success. They then classify these CSFs into seven categories and develop the success model shown in Figure 14.

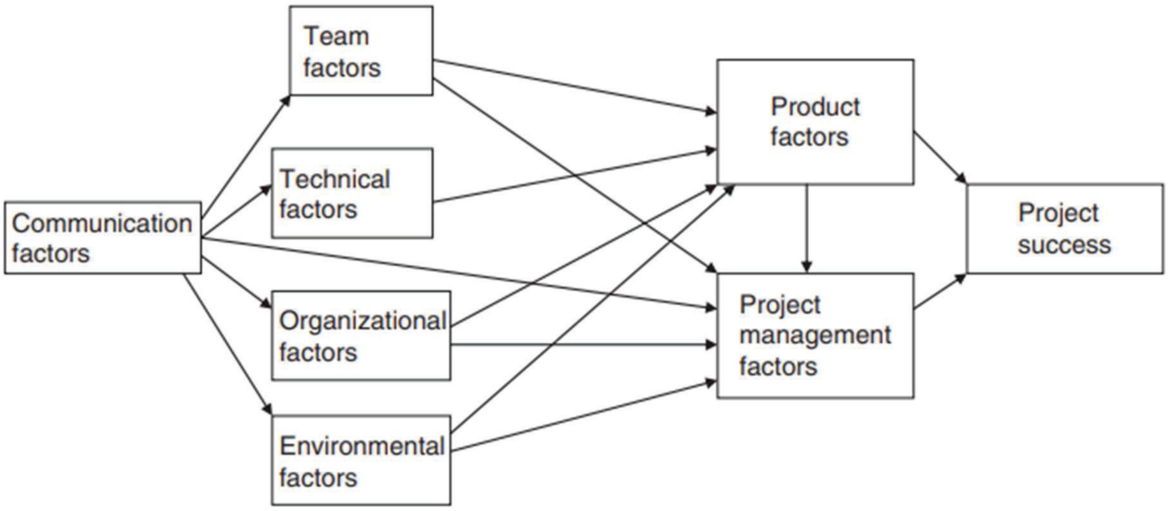


Figure 14. Conceptual Model of Critical Success Factors (Sudhakar, 2012)

Note. The arrows expressed in the model may not be regression relationships. In some cases, it may be an information flow as well.

The categorised CSFs identified in their research are shown in Table 12.

Table 12. Critical Success Factors of Software Development Projects (Sudhakar, 2012)

CSF category	Success factor identified
Communication factors	Communication in project Leadership Relationship between users and IS staff Reduce ambiguity Maximise stability
Technical factors	Technical tasks Troubleshooting Technical uncertainty Technical implementation problems integration of the system
Organisational factors	Top management support Realistic expectations Organisational politics Financial support Power
Environmental factors	User involvement Customer involvement Vendor partnership External environment events Client acceptance
Product factors	Accuracy of output Reliability of output Timeliness of output Quality control Documentation of systems and procedures
Team factors	Team capability/competence Teamwork Select right project team Project team coordination Task orientation
Project management factors	Project planning Project control mechanisms Project schedule Project manager's competence Clear project goal

2.4.14 ELS ET AL. (2012)

Els et al. (2012) aims to move beyond the conventional project success criteria and to expand the knowledge in the field, which leads to a model, as shown in Figure 15, that is largely based on previous literature.

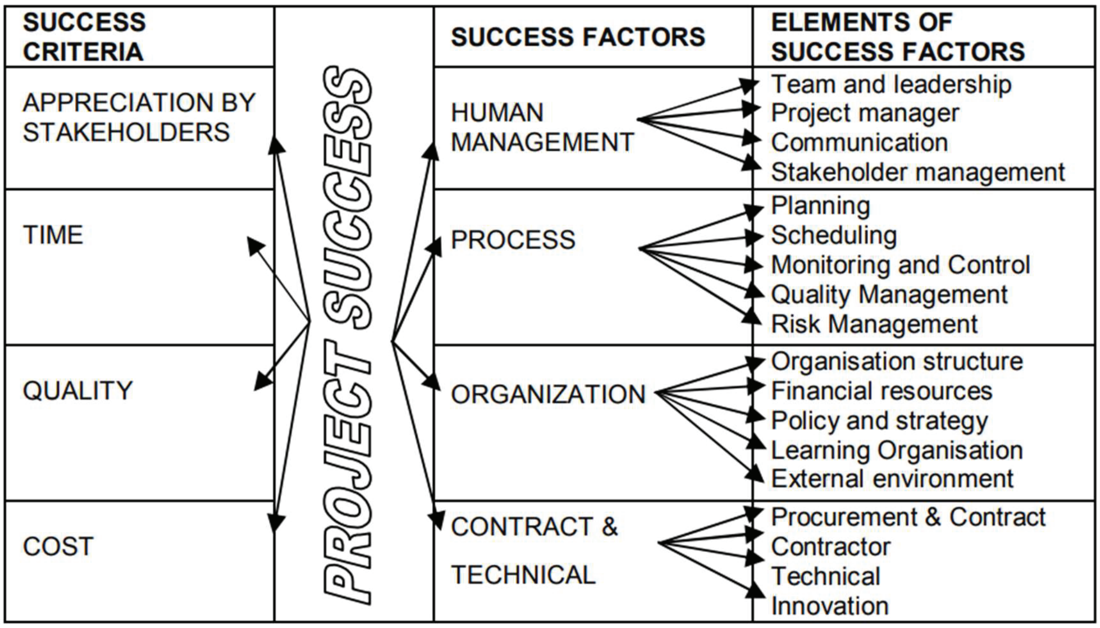


Figure 15. Project Success Model (Els et al., 2012)

This model is developed based on two aspects of project success: namely 'what to achieve' and 'how to achieve'. Similar to many other studies in the past, their work commences with exploring the literature to find the success criteria and a further survey among professionals and academics to quantify and rank the success criteria and factors in built environment projects. Thus, they define project success as achieving the success criteria of appreciation by stakeholders, completion on time, within budget and quality through the success factors of human management, process, contract and technical, and organisation.

In the context of project management in South Africa, Els et al. (2012) examines the model using questionnaires, and observes that stakeholder appreciation is perceived as the most essential among respondents and that respondents usually place a high priority on customer requirements.

2.4.15 HWANG & LIM (2013)

Hwang & Lim (2013) introduce a model for construction project success using CSFs shown in Figure 16. Despite having made some modifications, the CSFs they have included in their model are mainly adopted from Chua et al. (1999) that focused on the construction projects in

Singapore. However, there are some differences between these two. Hwang & Lim (2013) do not consider all the project's participants and only key stakeholders such as clients, contractors and consultants are taken into account, and for each participant, different success factors are identified.

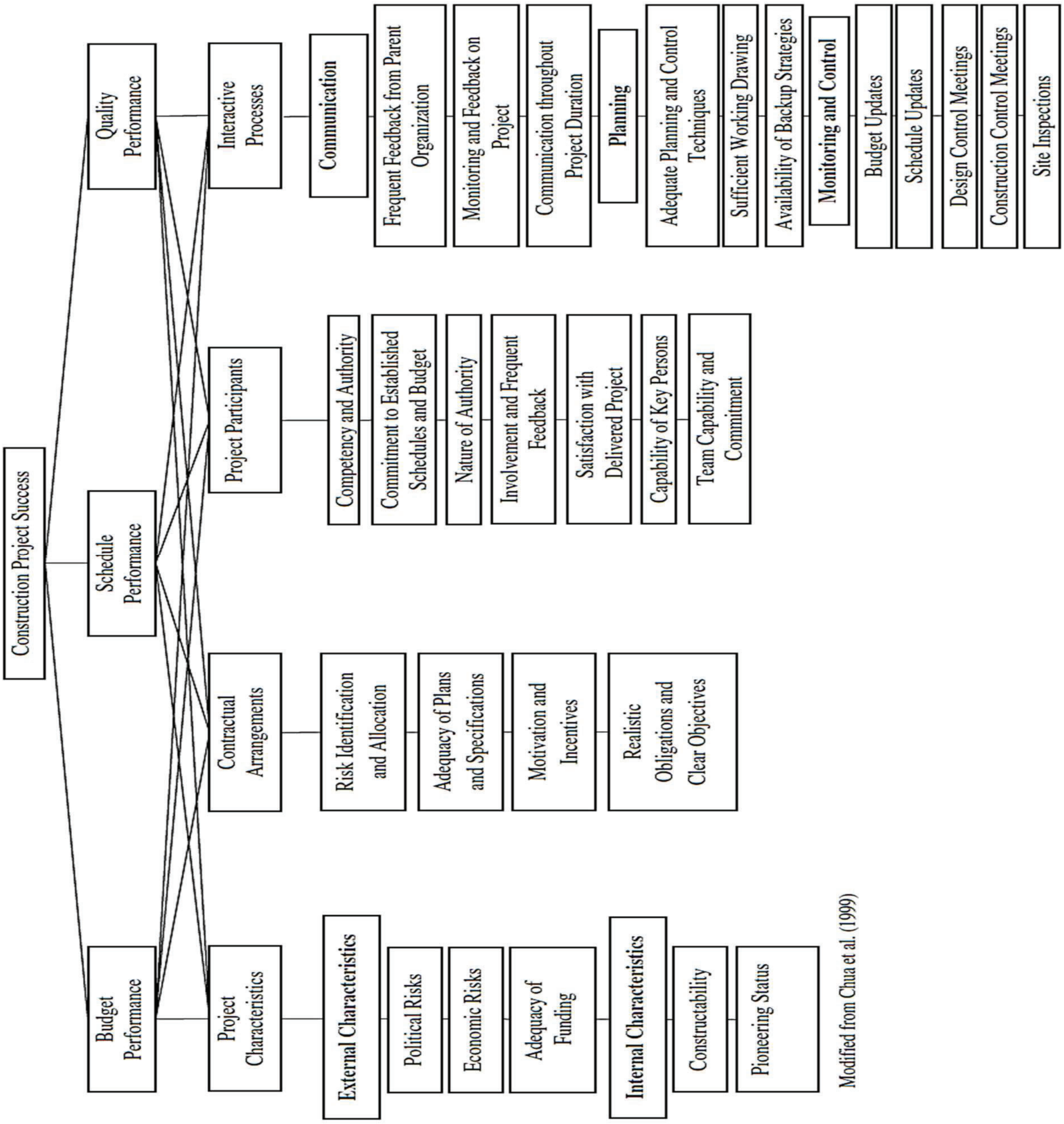


Figure 16. Hierarchical Model of Construction Project Success Factors (Hwang & Lim, 2013)

Regarding the implications and the benefit of their model to the industry, they state that the project leaders who intend to use the findings as a reference to develop tailored CSFs for their own construction projects may take it to practical application. They can also correlate the success factors found in this study to real success factors of their past projects. It might act as a performance improvement procedure in different organisations since it provides a clear baseline for the managers. Likewise, the project team can utilise the CSFs to measure their project's performance to secure more successful outcomes.

2.4.16 NGUYEN & CHOVICHIEN (2013)

Nguyen & Chovichien (2013) conduct research focused mainly on the Vietnamese construction industry, and develop a framework for project success as shown in Figure 17. They aim at the development of project success score concept to be able to measure project success as a quantifiable number to make it easier for an organisation to rank and compare their construction projects to each other. Hence, the completed project can act as benchmarks for future ones. Two surveys are undertaken to achieve this goal. The first study gathers information from 28 completed projects to determine the ability to collect information required to measure project success. The second survey gathers views from 65 participants on the level of importance and relevance of each index and subindex. One index and seven sub-indexes are removed from the list in the study analysis. The final list contains 11 indexes explicitly described by 46 sub-indexes. As a result, their study provides '*an innovative, practical list of indexes and sub-indexes for project evaluation. Although there are many models from previous studies to evaluate project success, the list in this paper has contributed additional components. List of indexes and sub-indexes was developed from three sources, which were the literature review (theory), previous documents of completed projects (industrial sources), and experts and respondents (academic and human opinions). Therefore, it was fully representative and objective. The list of indexes and sub-indexes were ensured that they could be evaluated by real information when the project completed. It helps to overcome the limitations of previous studies in practical evaluation*' (Nguyen & Chovichien, 2013, p.39).

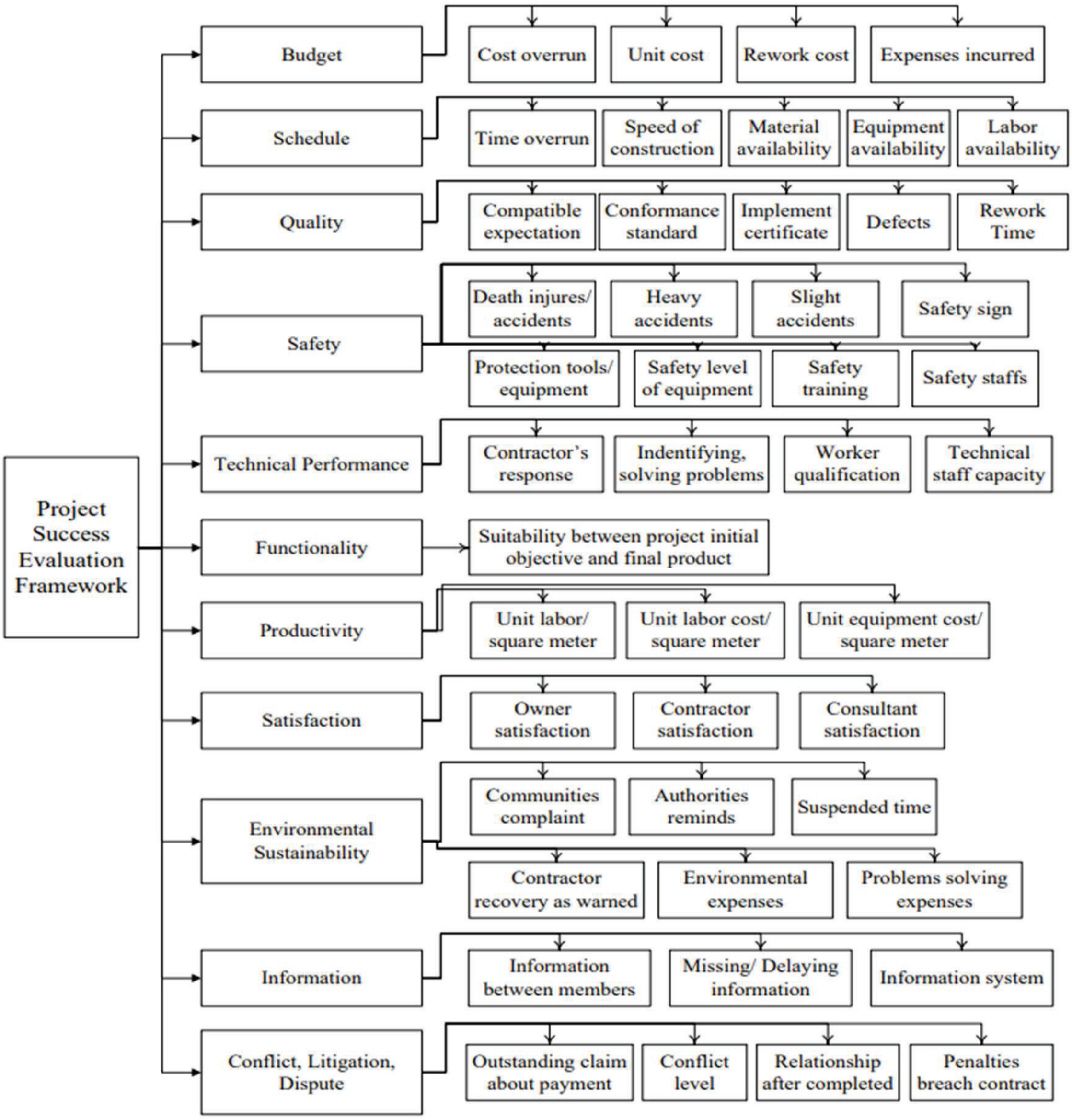


Figure 17. Project Success Evaluation Framework (Nguyen & Chovichien, 2013)

2.4.17 GUDIENĖ ET AL. (2014)

Similarly, Gudienė et al. (2014) explores and examines the construction industry in Lithuania and introduces a critical success factors model as shown in Figure 18.

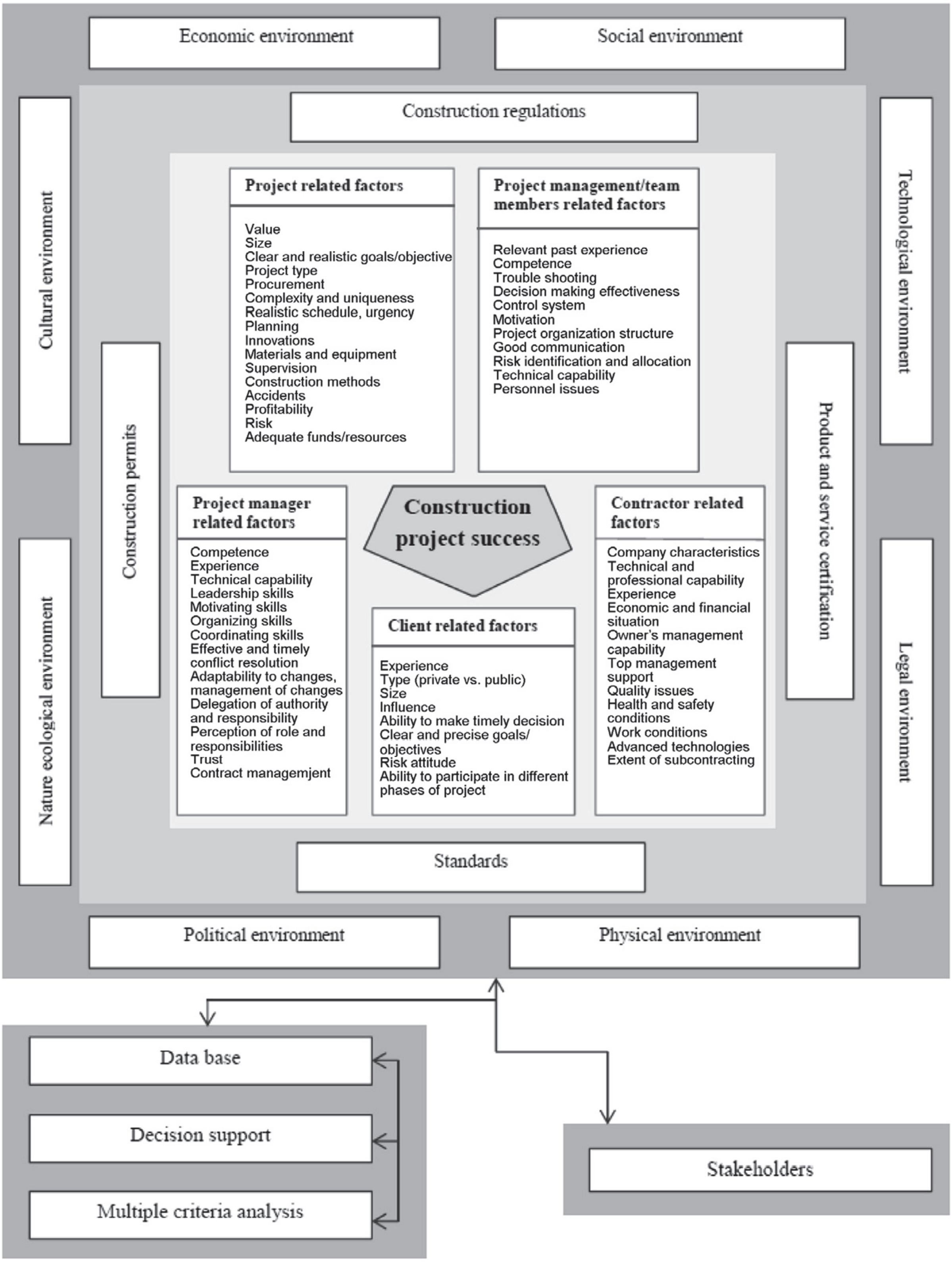


Figure 18. CSFs Model for Construction Projects (Gudienė et al., 2014)

This model consists of seven groups of critical success factors: external factors, institutional factors, projects related factors, project management/team members related factors, project manager related factors, client-related factors, contractor related factors. A factor in one group can affect the others in different groups.

This model is conceptual and only based on the literature; however, in further research, Gudienė et al. (2013) examines the importance of the CSFs in their model by surveying Lithuanian construction project managers. Ten factors including project manager competence, project management team members' competence, project manager coordinating skills, client clear and precise goals/objectives, project value, project management team members' relevant experience, project manager organising skills, project manager effective and timely conflict resolution, client ability to make timely decisions, and project manager's experience are concluded as the most critical success factors for construction projects in Lithuania.

2.4.18 HOWSAWI ET AL. (2014)

Howsawi et al. (2014) propose a framework (see Figure 19) for the definition and evaluation of project success. This framework comprises four levels of success criteria for projects (Howsawi et al., 2014, p.5), including:

- *Project Process:* This level contains the criteria used to judge the actions taken to provide the required deliverables. Examples of such criteria are meeting budget and schedule, and efficiency of execution.
- *Products and Deliverables:* This level contains the criteria used to judge the technical requirements and qualities of the products or deliverables resulting from the project. Examples of such criteria are technical validity, manufacturability and technical performance.
- *Business:* This level contains the criteria used to judge the benefits and returns (or losses) of the project to the stakeholders. Examples of such criteria are the contribution of the project to the strategic mission of the firm, preparing for the future, and satisfying the needs of the users.

- *Context and Externalities:* This level contains the criteria used to judge the project based on compliance with the contextual circumstances and externalities that affect it, such as the political situation, regime and climate. The project team or organisation has little or no control over these externalities.

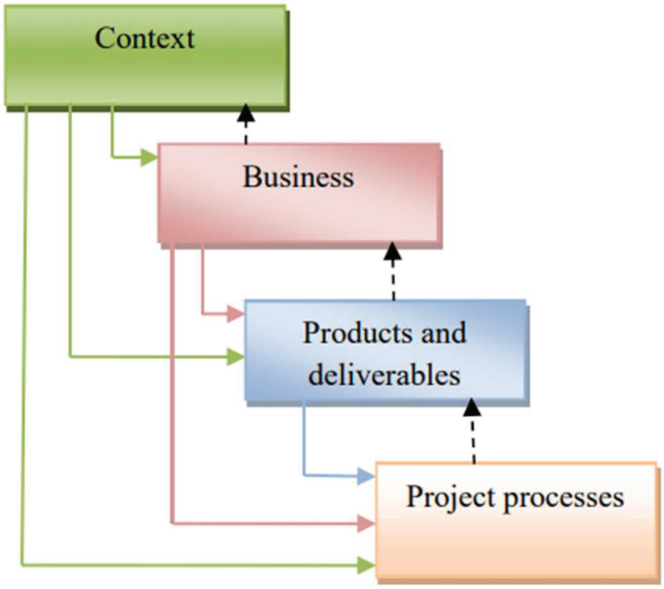


Figure 19. The Four-level Framework (Howsawi et al., 2014)

Howsawi et al. (2014) describe the main characteristics of their model as follows:

- This framework can assess project performance at various stages of the project or the overall project success. Hence, poor performance at one stage would not necessarily mean an overall project failure.
- Success in the higher levels has a more significant effect on the overall project success.
- A lower-level performance might affect a higher level's result, but the vice versa is certain.
- A particular criterion can be shared at different levels, but the measures might differ from one level to another.

- At a lower level, the assessment requirements are connected to those at a higher level. Any adjustment at the higher level affects the level beneath. The magnitude of change at a lower level relies on the value of the change at a higher level.
- The criteria and the assessment might evolve and change over time.
- All the criteria at higher levels must be met within the assessment of lower levels.
- The criteria at the higher levels have the edge over the ones at the lower levels when contradictions occur.

2.4.19 GOLLNER & BAUMANE-VITOLINA (2016)

Many success models have been created for particular project types such as this one that Gollner & Baumane-Vitolina (2016) develop using empirical data for measuring Enterprise Resource Planning (ERP) project success, as shown in Figure 20. They state that ERP project success is mainly a combination of project management success and project product success. In their research, they attempt to cover all critical dimensions surrounding ERP projects. It indicates that characteristics of success factors could be classified into five different aspects, namely project management, user satisfaction, time and budget, ERP system quality and economic value. There are some level of interconnections existing among these dimensions and might logically be correlated. They employ factor analysis to reveal these connections and underlying relationships. The numbers in the model (percentages) indicate the value of variables that each dimension explains.

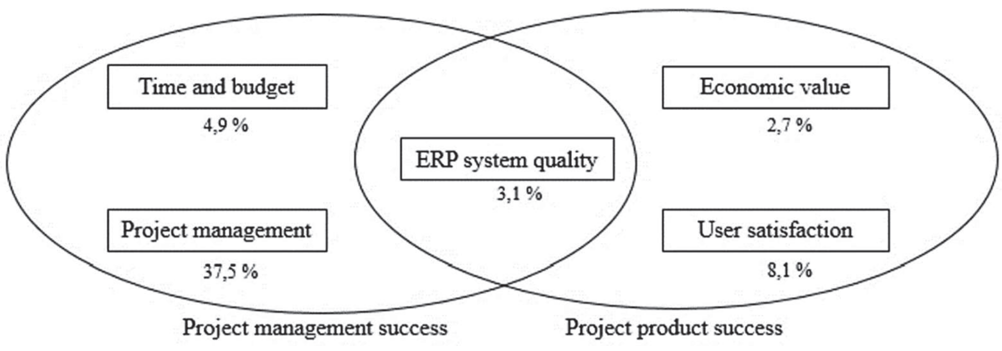


Figure 20. ERP Project Success Measurement (Gollner & Baumane-Vitolina, 2016)

2.4.20 DOSKOČIL ET AL. (2016)

Doskočil et al. (2016) present a new expert decision-making fuzzy model for the evaluation of project success (EDMS_PSU), as shown in Figure 21. It consists of three sub-models: a fuzzy model of project state evaluation (EDMS_PS), a fuzzy model of total project risk evaluation (EDMS_TVPR), and a fuzzy model of project quality evaluation (EDMS_PQ). There are six input variables, four rule blocks and one output variable in the fuzzy model. The rule block RB1 evaluates project status (PS) based on the Earned Value Management (EVM), specifically the indexes SPI and CPI. EVM method is based on the following indices:

> *Planned value (PV) – The budgeted cost of work scheduled (BCWS). The total PV of a task = the task's budget at completion (BAC).*
>
> *Earned value (EV) – The budgeted cost of work performed (BCWP).*
>
> *Actual cost (AC) – Actual cost of work performed (ACWP).*
>
> *EVM id used for describing project schedule and cost performance following basic indices: Schedule variance (SV) – shows whether and by how much your work is ahead of or behind your approved schedule. Mathematically: SV = EV – PV.*
>
> *Cost variance (CV) – shows whether and by how much you're under or over your approved budget. Mathematically: SV = EV – AC.*
>
> *Schedule performance index (SPI) – shows the relative amount the project is ahead of or behind schedule. Mathematically: SPI = EV / PV.*
>
> *Cost performance index (CPI) – shows the relative value of work done compared to the amount paid for it. Mathematically: CPI = EV / AC.*

The rule block RB2 evaluates the total value of project risk (TVPR) on the RIPRAN (RIsk PRoject ANalysis) method – specifically the indicators: Number of Sub-Risk and Total Value of Sub-Risks. Both indicators are extremely important inputs in the evaluation of the total risk of the project based on the RIPRAN method. The RIPRAN method is an empirical method for the analysis of project risks (Doskočil et al., 2016).

The inputs (into RB2) are represented by two variables: Number of sub-risk (NSR) and the total value of sub-risks (TVSR). The output variable is the total value of project risk (TVPR). The input variable NSR has five attributes: VS – very small, S – small, M – medium, L – large, VL – very large. The input variable TVSR has five attributes: VS – very small, S – small, M – medium, L – large, VL – very large. The output variable TVPR has five attributes: VS – very small, S – small, M – medium, L – large, VL – very large.

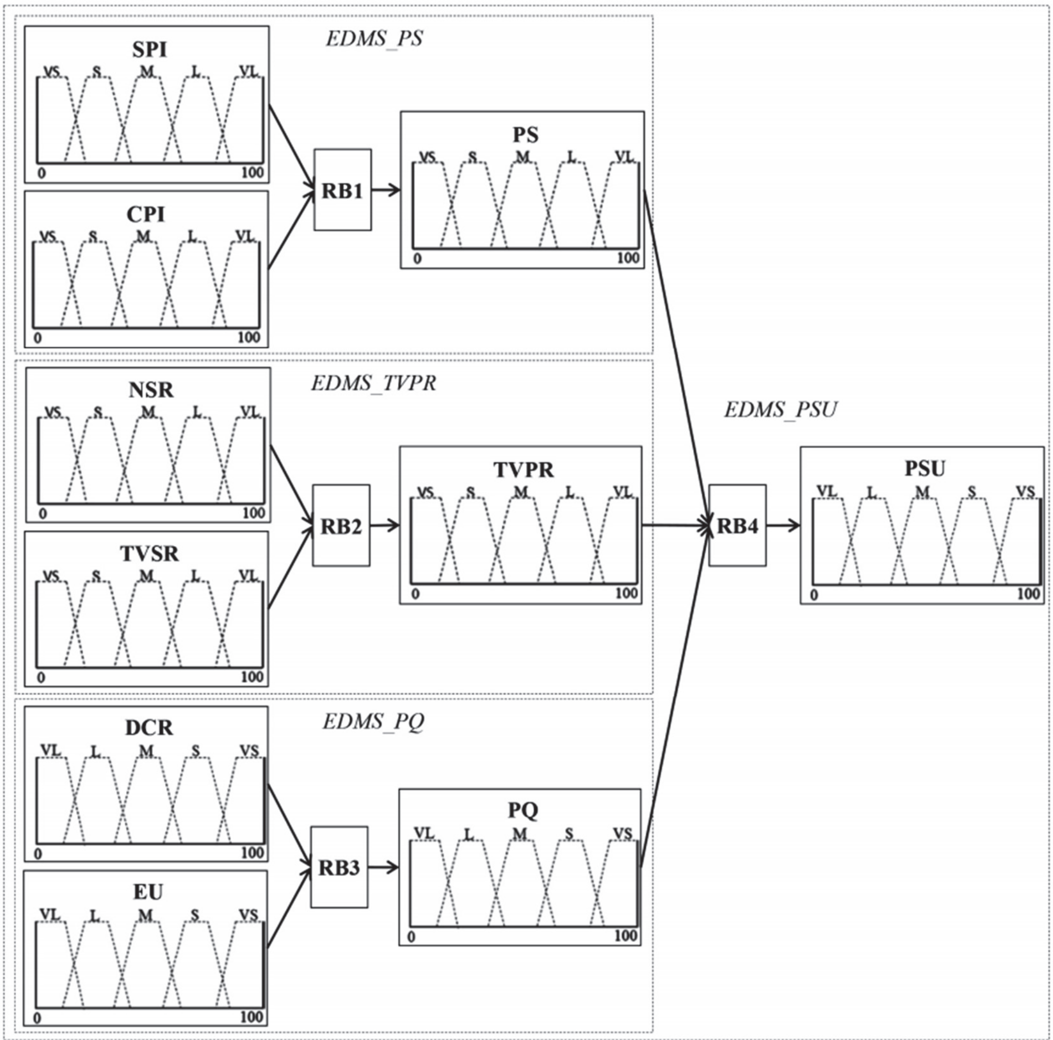


Figure 21. Fuzzy Model for the Evaluation of Project Success (Doskočil et al., 2016)

The inputs (into RB3) are represented by two variables: Degree of compliance with the requirements (DCR) and eligibility for use (EU). The output variable is project quality (PQ). The input variable DCR has five attributes: VL – very large, L – large, M – medium, S – small, VS – very small. The input variable EU has five attributes: VL – very large, L – large, M – medium, S – small, VS – very small. The output variable PQ has five attributes: VL – very large, L – large, M – medium, S – small, VS – very small.

Rule block RB4 evaluates project success (PSU). Partial outputs from the blocks (RB1, RB2, RB3) are simultaneously inputs into rule block RB4. The output variable is project success (PSU). The output variable PSU has five attributes: VL – very large, L – large, M – medium, S – small, VS – very small (Doskočil et al., 2016).

Regarding the implications of their model, (Doskočil et al., 2016) explain that the framework supplies project managers and other participants with a method to 'measure' specified project processes (e.g. project risk assessment, quality evaluation project success assessment). The fuzzy method, which involves a knowledge base of expert principles and its ability to assess three key criteria of project success systematically hierarchically and extensively, is the key advantage and at the same time varies from existing ones. The ability for further model experimentation in the form of a simulation, for instance, is a considerable general benefit of the incorporation of the modelling methodology to project management. It provides additional knowledge on potential alternative development of projects and provides warning signals to support future decision-making.

2.4.21 DAVIS (2018)

After a series of research studies on the stakeholders' view on project success (Davis, 2014; Davis, 2016; Davis, 2017; Davis, 2018), she presents a multiple stakeholder model, based on empirical data, to measure the differing views of project success. Her aim is to improve awareness of the assessment of project success and promote a common perspective between participants to maximise the success rate.

The model comprises three stages: (1) the use of key questions addressing three new dimensions answered by each project stakeholder group anonymously; (2) the responses are gathered by the impartial administrator; and (3) the project manager's findings are applied to determine the measurements used for success which can be modified to satisfy evolving goals throughout the project (see Figure 22).

Dimensions	Statement	Answer
Leadership	There is consistent consensus on how to judge the project's success.	
	I trust the project's sponsor and leadership team to create the conditions for the project's success.	
	I am confident that the project will be successful.	
	During the good and bad times ahead, I trust the project's leaders to listen to me and keep me informed.	
	I am motivated to make this project a success and to go the 'extra mile' when necessary.	
	When something goes wrong, I am blamed.	
	Senior leaders have taken ownership of the project's risks and accepted ultimate accountability for its outcome.	
	This project's stakeholders have been correctly identified, prioritized, and engaged.	
	I agree with the way the status of the project is being reported.	
	Leaders react effectively to changes in the project's status and circumstances.	
Organization	The owning organization is responsive to the project's customer needs and expectations.	
	The organization has the capability to successfully execute a project of this type and complexity.	
	The project's objectives are aligned with the organization's strategy.	
	The project's objectives are realistic given current and foreseeable operational pressures and constraints.	
	The organization's processes and systems adequately support the project's reasonable needs.	
	HR's performance management and reward/recognition processes ensure that the success of the project benefits me.	
	I trust the project's management team and associated line managers to collaborate to resolve inevitable problems and setbacks.	
	Third-party groups and suppliers are engaged and ready to support the project's success.	
Team	The project team has a common sense of purpose and is focused on the project's objectives.	
	The project team has been fully consulted during the definition, planning, and estimating of this project.	
	The project team is trusted and empowered to get the job done.	
	Morale is generally high across the project team.	
	The project team is energized and working effectively.	
Project Management Essentials	An independent expert has reviewed the way the project is organized, planned, monitored, and controlled. Corrective and improvement action is taken as a result.	

Figure 22. Multiple Stakeholder Model (Davis, 2018)

2.4.22 JANKUNAITE & BELEVICIENE (2019)

The last model is a framework created by Jankunaite & Beleviciene (2019), as shown in Figure 23. It aims to measure success within the international cultural projects. This model consists of a project related, project coordinator related, used art forms, international team, international cooperation tools, communication, external environment factor groups and three criteria: time, quality and cost. The model is based on the distinguishing features of the global or social project, and the critical success factors from most of the previous studies are included in the different dimensions of it.

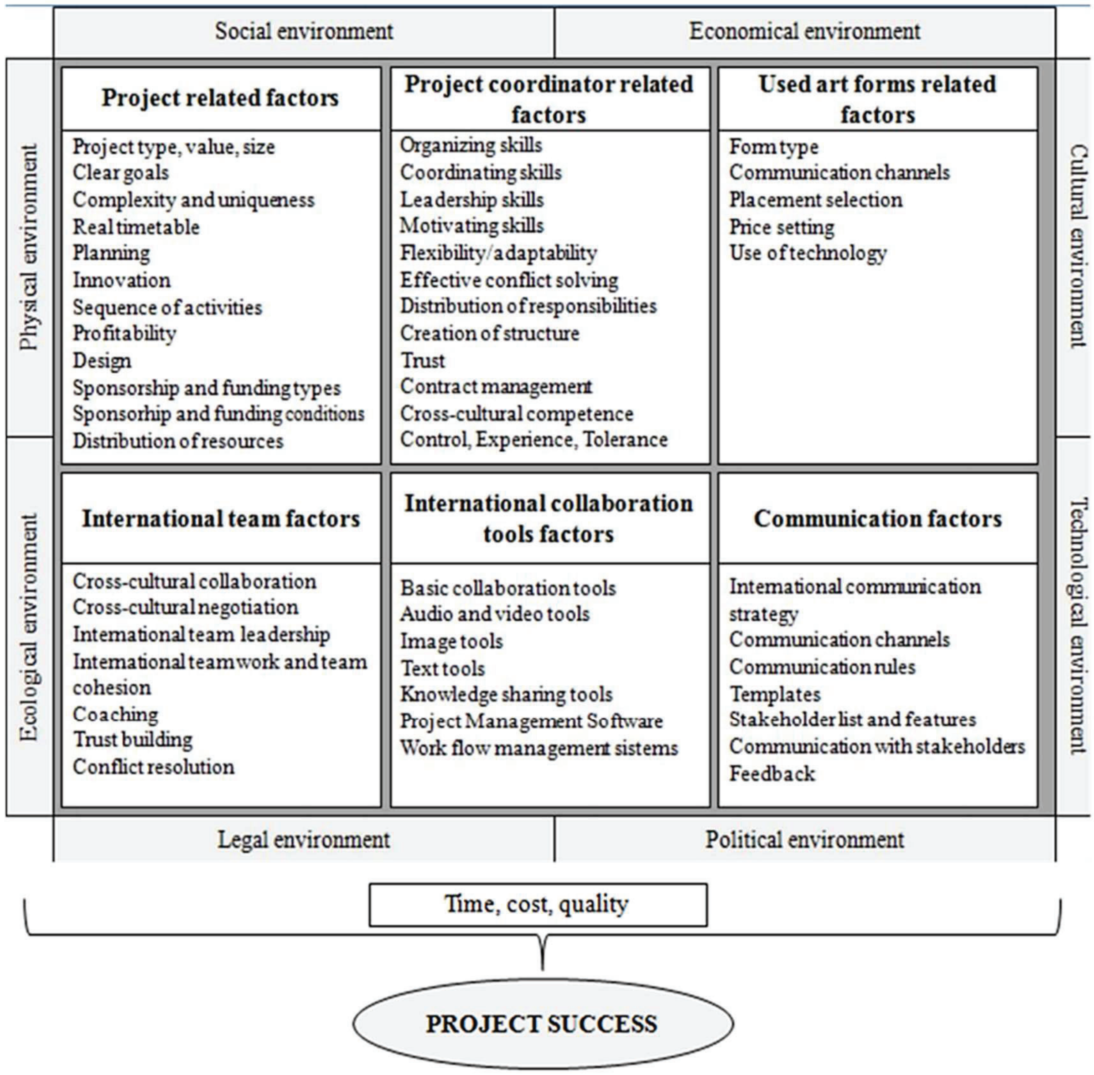


Figure 23. Project Success Evaluation Model (Jankunaite & Beleviciene, 2019)

According to Albert et al. (2017), the lack of standardisation in assessing the success of projects leads to irreconcilable judgments of performance. In fact, two different approaches to evaluate the same project could lead to different outcomes of success or failure. Therefore, because of differing definitions, assessing project success is a partially subjective matter. Further research should be done to prevent significant success measurement inconsistencies. A generic framework should be introduced to define project success and provide a universal guideline on performance measurement.

2.5 LANGSTON'S 3D INTEGRATION MODEL

The 3D integration model (Langston, 2013) for describing project integration takes the form of a tetrahedron containing all knowledge areas existing in the *PMBOK® Guide* (Fifth Edition), plus a new area of project environmental management to recognise the emerging importance of sustainability in modern projects. It is shown in Figure 24.

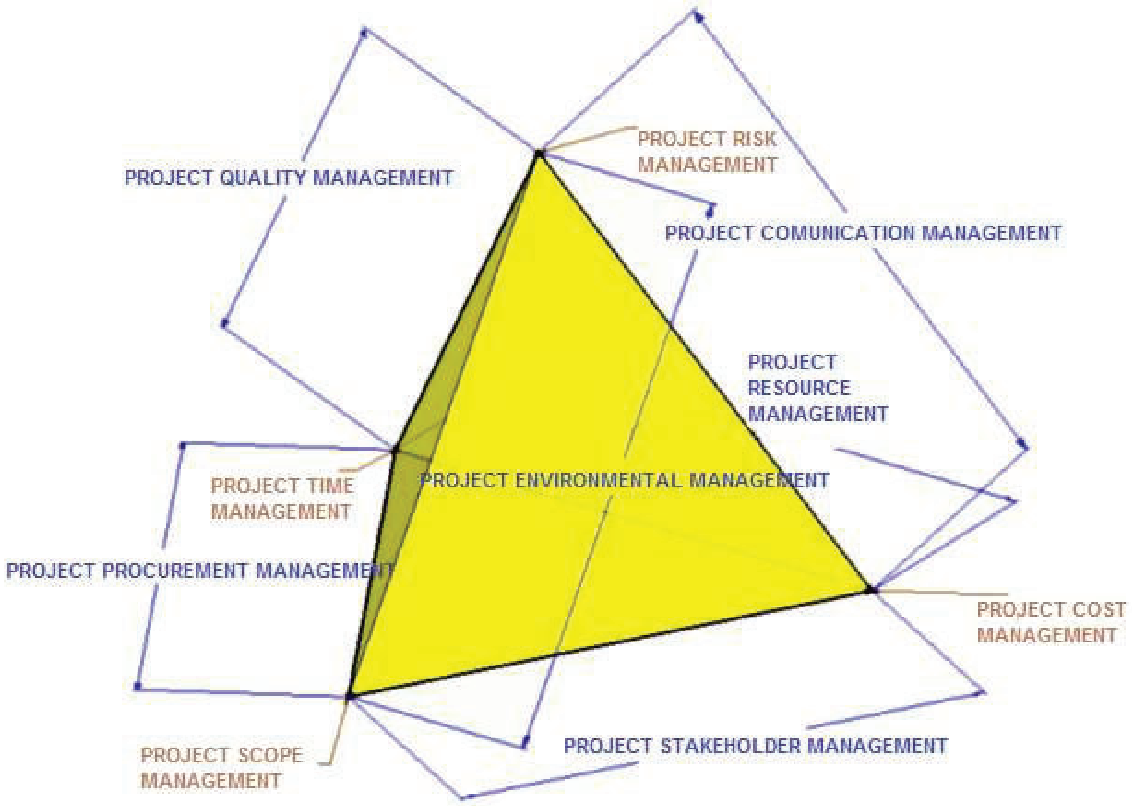


Figure 24. 3D Project Integration Model (Langston, 2013)

He contends this model can be used to assess the performance of project teams in delivering successful outcomes at various stages in the project life cycle through the identification of core project constraints (occupying the four vertices of the model) and six KPIs (represented by the edges of the model). KPIs express the relationships between constraints, are relevant to any type of project, and are capable of objective measurement (Langston, 2013).

This 3D project integration model includes six generic KPIs that are related to project delivery success (PDS), and comprise:

1. *Value*. Defined as the ratio of scope over cost (objective: *maximise*). Value is a function of Project Stakeholder Management, namely meeting expectations and fostering engagement. Scope is treated as an output and cost is treated as an input, so the more utility per unit of cost the greater is the value for money.

2. *Efficiency*. Defined as the ratio of cost over time (objective: *maximise*). Efficiency is a function of Project Human Resource Management, namely, team performance and leadership. Cost, in this case, is treated as an output (value of work completed) and time as an input, so the more money spent per unit of time the more efficient is the delivery process.

3. *Speed*. Defined as the ratio of scope over time (objective: *maximise*). Speed is a function of Project Procurement Management, namely outsourcing strategies and parallel supply chains. Scope is treated as an output and time as an input, so the more utility provided per unit of time the faster is the delivery process.

4. *Innovation*. Defined as the ratio of risk over cost (objective: *maximise*). Innovation is a function of Project Communications Management, namely knowledge management and research-informed learning. Risk is treated as an output (innovation leads to development risks) and cost as an input, so a higher level of risk per unit of cost reflects the search for better ways of doing things.

5. *Complication*. Defined as the ratio of risk over time (objective: *minimise*). Complication (originally ‘complexity’) is a function of Project Quality Management, namely excessive quality assurance paperwork and engineering over design. Risk is treated as an output and time as an input, so a higher level of risk per unit of time is a sign of project difficulty that should be avoided.

6. *Impact*. Defined as the ratio of risk over scope (objective: *minimise*). Impact is a function of Project Environmental Management (proposed), namely adverse sustainability outcomes and unnecessary resource consumption. Risk is treated as output and scope as an input, so a higher risk level per unit of utility reflects unwanted environmental disruption.

The relationships among the core project constraints of cost, time, scope and risk and the KPIs of value, efficiency, speed, innovation, complication and impact are illustrated in Figure 25.

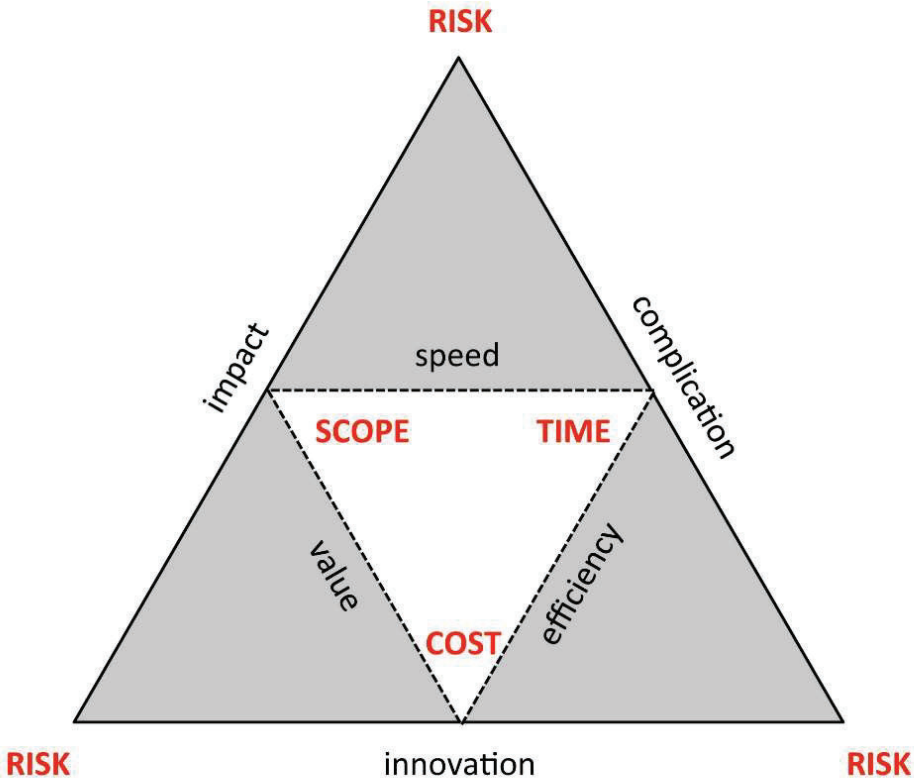


Figure 25. Project Constraints and Key Performance Indicators (Langston, 2013)

A 2D version of the model is presented here for ease of comprehension, but it turns into a 3D tetrahedron by 'folding' along the dotted lines. Core project constraints, which are equally weighted, are shown in upper case. Clearly, it is impossible to optimise all KPIs, given that most constraints act as outputs in some cases and inputs in other cases (Langston, 2013).

Overall success (computed as the change in PDS between planned and actual performance) is given by the following formula (Langston, 2013):

$$Project\ Delivery\ Success\ (PDS) = \frac{s^3}{ctr}$$

where s = scope baseline, c = cost baseline, t = time baseline and r = risk baseline

In recent years, the importance of environmental sustainability has emerged and captured the attention of project management teams (Ebbesen & Hope, 2013; Fernández-Sánchez & Rodríguez-López, 2010; Hwang & Lim, 2013). The construction industry has a significant influence on the environment and society and is a major sector involved in achieving sustainability (Shi et al., 2012), but environmental impact applies to all activities regardless of industry sector. Not only are environmental controls likely to impact on project outcomes and choices, but the wider moral imperative of a sustainable future has led to concern that the balance between economic, social and environmental criteria (i.e. TBL thinking) is not well served by the current *PMBOK® Guide*. In much the same way that stakeholder management was separated from communications management and elevated to higher importance in newer editions of the guide, so too will environmental management need to be extracted from scope, quality, procurement and risk management and given more prominence and coherence. Sustainability considerations are paramount to our collective future.

Langston (2013) uses the four vertices of the tetrahedron to represent core project constraints of scope, cost, time and risk and the six edges to represent KPIs of value, efficiency, speed, innovation, complication and impact. The four faces of the tetrahedron were not ascribed meaning. The 3D integration model is later extended (Ghanbaripour et al., 2017) to add TBL as an integral part of the measurement of project delivery success, effectively forming a fifth core project constraint. Each face of the tetrahedron can reflect an aspect of sustainable development. Beech (2013) proposes the '4Ps' approach to measuring sustainability: profit, people, planet and progress. When applied to this model, the three KPIs bounding each face simplify to respective performance indices (as shown in Figure 26).

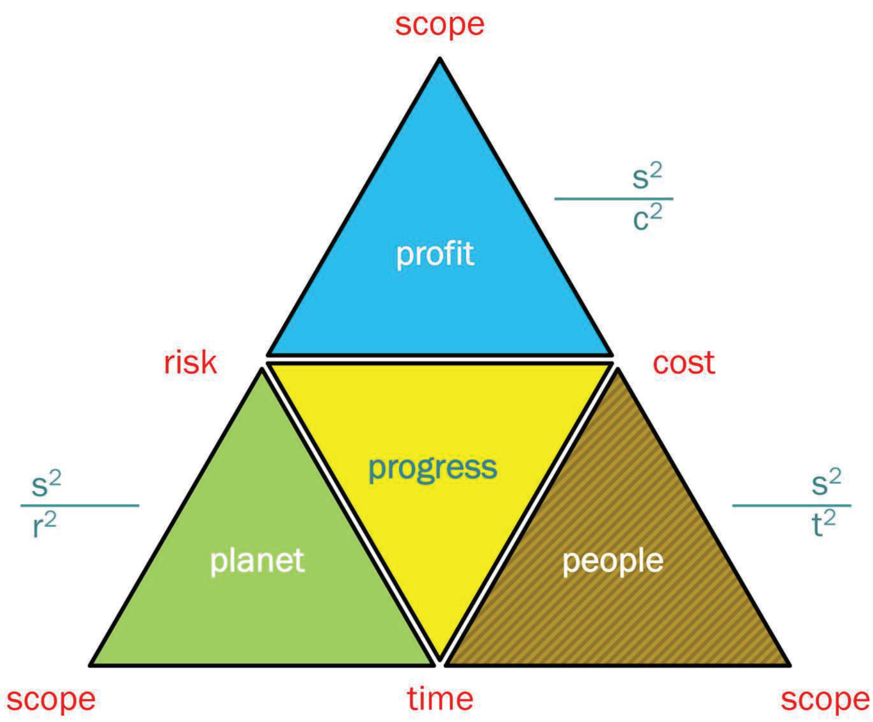


Figure 26. TBL Reporting Applied to 3D integration Model (Langston, 2013)

For example, the face called 'profit' is bounded by the KPIs of value, innovation and impact. Value (scope over cost) and innovation (risk over cost) need to be maximised, while impact (risk over scope) needs to be minimised. When multiplied together, this reduces to s^2/c^2. Projects should be progressive, not regressive, and this can be assessed by the average of profit, people and planet indicators being positive. Balancing TBL forms the fifth constraint to measuring success by embedding ethical behaviour into procurement decisions. Indeed, 'doing the right project' is arguable more important that 'doing the project right'.

As explained, 'profit' is a function of both scope and cost (i.e. s^2/c^2), and hence has similarities with the measurement of the value KPI, which seems perfectly reasonable given a context of economic performance. Likewise, 'people' is a function of scope and time (i.e. s^2/t^2) with connections to the speed KPI and contributes to social performance by ensuring that projects are procured in a timely fashion so that their benefits to society are realized sooner. From an environmental perspective, 'planet' combines scope and risk (i.e. s^2/r^2) and hence displays similarities to the impact KPI. In all three cases, if scope increases and either cost, time or risk decrease, then TBL performance is enhanced.

Ethical behaviour by project managers is modelled by the computed value of 'progress'. Progress is a combination of efficiency (i.e. c/t), innovation (i.e. r/c) and complication (i.e. r/t), where the latter is minimised while the others are maximised. Progress has no unit, as is seen by multiplying c/t with r/c and dividing by r/t. For this reason, the average of the profit, people and planet parameters is used to measure progress. The answer must be positive. Furthermore, not only should profit, people and planet be equally weighted, but an even balance between them would be ideal. This may not always be possible or even desirable. For some projects, profit may be a low priority. Where it is appropriate, however, the balance might be judged by ensuring the percentage change between planned and actual performance for the highest scoring criteria is not more than double the lowest-scoring criteria, assuming both are positive numbers. The inclusion of TBL into the 3D integration model completes it conceptually and enables projects to be assessed not only in terms of their PDS score (higher the better) but also on their TBL score (positive and balanced).

Project Integration Management, a key knowledge area in the *PMBOK® Guide*, is intended to ensure that the right balance between all other parts of a project is achieved. In essence, it assesses scope, time, cost, quality, human resource, communications, risk, procurement, stakeholder (and now environment) holistically. The 3D nature of the model itself reflects how such integration is handled. By incorporating all *PMBOK® Guide* knowledge areas together, all aspects of project delivery and sustainability are embedded, so the argument to include further issues is diminished.

The key point here is that the four core project constraints (scope, cost, time and risk) and six KPIs (value, efficiency, speed, innovation, complication and impact) in the 3D integration model are generic and apply to every project type. While the PDS score is based on the generic set of KPIs, there is no reason why secondary KPIs cannot be used to also measure success. These can be treated separately. For example, if the level of disputes on site is important (perhaps due to industrial relations or design change), then a new KPI can be employed based on the number of disputes per month. Obviously minimising this KPI would be of benefit, and a target of one dispute per month might be a goal of the project manager. However, the six KPIs described early should be considered as mandatory and form a mechanism to enable projects to be compared and ranked for project success within an organizational portfolio, or ultimately at a regional, national or international level. This is a benefit no previous success model or paradigm can claim. The addition of TBL makes the model even more powerful.

The literature, however, does frequently note that project satisfaction is an important criterion for success. Obviously, satisfaction is a generic concept and can apply to all project types. It is undoubtedly relevant. Logically stakeholder satisfaction will be realized when the PDS score is better than forecast. Yet it is conceivable that even if all KPIs are delivered, one or more stakeholder groups may remain dissatisfied. Perhaps specific stakeholders had objectives that conflicted with the way the project manager made decisions based on the recognized power and influence of most stakeholders. Therefore, the question arises as to whether stakeholder satisfaction is a success criterion or a phenomenon. The latter is suspected. Given that satisfaction of the project's designed performance can be difficult to untangle from satisfaction with the delivery process, attempting to embed satisfaction formally in the 3D integration model is considered unwise.

As noted above, the 3D integration was extended by Ghanbaripour et al. (2017) to incorporate TBL as the fifth core project constraint. In order to merge the model into *i3d3* and to take into account the project complexity factor in calculating the PDS score, it has been extended again. In order to assess the likely position of a new project on the complexity continuum, a means of scoring key project variables has been established. Langston & Dhaduk (2019) propose a novel forecasting tool that can be applied at the project initiation phase to determine expected complexity, represented by a number between 1 and 27 inclusive. Known as the *Complexity Forecasting Cube* (CFC), it takes the form of a 3D matrix that reflects simple (low score) to chaotic (high score) projects based on X, Y and Z coordinates.

The CFC model draws on previous literature to derive the three generic key project variables, each being assessed using a score of low, moderate or high to reflect its potential complexity:

- X coordinate: the scale of the challenge (low = local, moderate = regional/ national, high = international)
- *Y coordinate:* the extent of uncertainty (low = mostly known knowns, moderate = many known unknowns, high = many unknown unknowns)
- *Z coordinate:* the diversity of stakeholders (low = single client, contractor and/or market, moderate = multiple clients, contractors and/or markets, high = broad community of project stakeholders displaying a wide range of interests and power)

Figure 27 summarises the proposed model, which is akin to a Rubik's cube (3x3x3 matrix). Each row of the cube is shown separately for greater clarity. The forecasted complexity score (computed as the multiplication of all three coordinates) signifies if a project is likely to be seen as simple (1-2), low complexity (3-4), complex (5-8), high complexity (9-15) or chaotic (16-27). Darker colours indicate higher complexity.

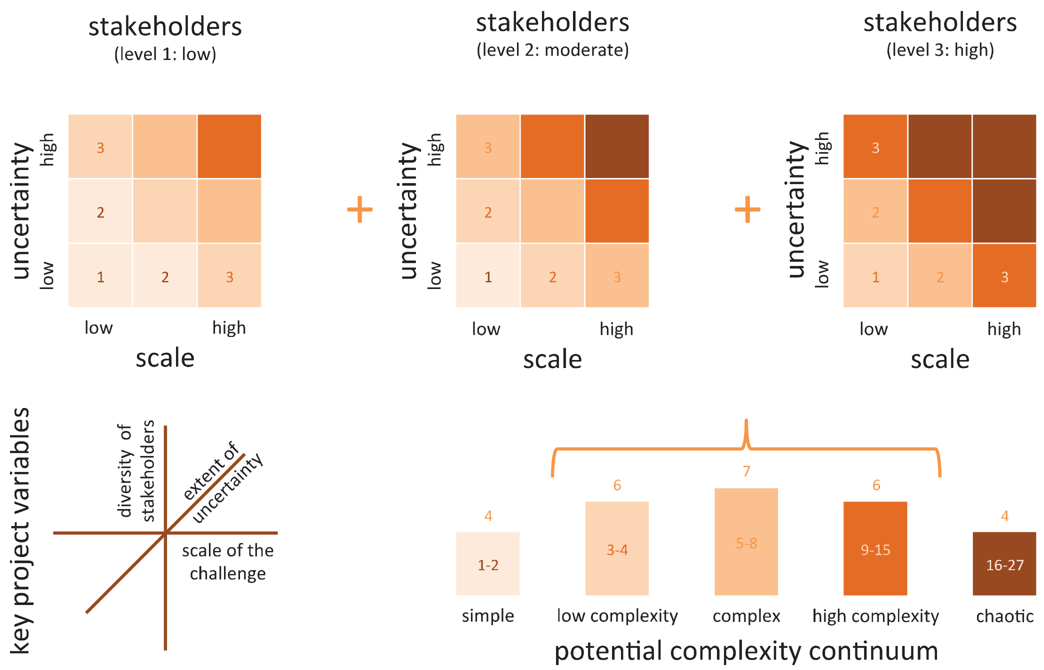


Figure 27. Generic CFC model (Langston & Dhaduk, 2019)

Projects that are potentially simple are likely to be managed using largely linear methods and well-documented management techniques. The range of complex projects is likely to require more sophisticated planning regimes (especially in regard to risk and stakeholder engagement). Where the scale is expected to be high, a Waterfall (or pre-planning) mindset may be more appropriate. Alternatively, where uncertainty is expected to be high, an Agile (or adaptive) mindset may be more appropriate. Projects that are potentially chaotic are likely to be managed as interacting systems using modelling tools to improve knowledge of causal relationships and their dynamic and shifting nature over time.

The complexity puzzle can be interpreted as a Rubik's-like cube, where the three dimensions to be measured, focus on project scale, uncertainty and stakeholders. The CFC model is primarily designed to apply to individual projects, but it can also apply to groups of aligned projects (i.e. program) or groups of projects and programs (i.e. portfolio) by changing the previous X coordinate assessment to reflect the scale of the management challenge (low = project, moderate = program, high = portfolio).

The link between project complexity and project success is under-explored. So it is likely that interest in these two highly scrutinised topics is set to continue for many years. Appropriate management approaches for dealing with complexity need to be identified early. This is especially true for future projects that are considered too big or too important to fail. Solving the complexity puzzle is key.

2.6 RESEARCH GAP

The review of the extensive body of literature related to project success, especially in construction industries around the world, demonstrates the importance and significance of this research area. Literature indicates that there is significant disagreement regarding the definition of project success, success criteria and CSFs, leading to numerous conceptual models and frameworks being developed (Hwang & Lim, 2013). Table 13, in which the success models proposed by researchers over the past thirty years have been reviewed, indicates that Barnes' iron-triangle is still an integral piece of all the models. According to Albert et al. (2017), the criteria to measure project success is not yet clear to enable proper project assessment. Thus, despite all these efforts made throughout these years, the question still exists: what criteria should be used for project success assessment? Albert et al. (2017) also investigated past project success models in 2017 when this research started. A thorough look at the models shows that most of them are based on conceptual ideas. Only a few models offer clear criteria that can be measured quantitatively and supporting comparison between different projects. For instance, when safety is referred to as a criterion, what would be deemed a failure? What is the number of injuries at the construction site? Is it dependent on the project size? Would a massive construction project be considered successful and safe if zero injuries occurred? If only one injury took place, what would the outcome be? Safety can be objective and measurable, but it is not clear whether absolute safety is a success, or just minor injuries, or the number of risks properly addressed is desired. Therefore, the project managers should be able to measure project success quantitatively, and only a little research has been done to enable managers having an assessment tool in hand to do so.

Table 13. Project Success Models developed over the Past 30 Years.

No.	Success Model	Success Criteria	Project Size	Project Type	Theoretical or Validated?	Number of Citations
1	Nicholas (1989)	Time, Cost, Performance, Quality, Safety	Any	Any	Based on academic studies and anecdotal reports	61
2	Belassi & Tukel (1996)	CSFs related to PM, team members, project, organization, external environment	Any	Type sensitive	Validated	
3	Lim & Mohamed (1999)	Completion and satisfaction	Any	NS	Theoretical	970
4	Turner (1999)	Context, sponsorship, attitude, definition, people, systems, organisation	Any	NS	Validated	1897

No.	Success Model	Success Criteria	Project Size	Project Type	Theoretical or Validated?	Number of Citations
5	Chan et al. (2002)	Time, cost, health and safety, profitability	Any	Construction projects	Theoretical	467
6	Westerveld (2003)	Result areas (budget, schedule, quality, Appreciation by the client, Appreciation by project personnel, Appreciation by users, Appreciation by contracting partners, Appreciation by stakeholders) and organisational areas (Leadership and Team, Policy and Strategy, Stakeholder management, Resources, Contracting, Project management)	Any	Any	Theoretical	748
7	Fraser & Turner (2002)	Project management, project selection, project success	Any	Any	Theoretical	2
8	Kendra & Taplin (2004)	the project manager skills and competencies, organisation structure, measurement systems, and management practices that represent an organisation's culture	Any	Inform-ation techno-logy projects	Validated via opinion-based survey	382
9	Shenhar & Dvir (2007)	efficiency, impact on the team, impact on the customer, business success, and preparing for the future	Any	Any	Validated	1250
10	Bannerman (2008)	process success, project management success, product success, business success, and strategic success	Any	Any	Validated (case examples of information systems projects)	83

No.	Success Model	Success Criteria	Project Size	Project Type	Theoretical or Validated?	Number of Citations
11	Khang & Moe (2008)	Identified CSFs in different stages	Any	Internat-ional develop-ment projects	Validated (a field survey conducted in selected Southeast Asian countries)	376
12	Turner & Zolin (2012)	Different success criteria from various stakeholders' perspectives	Large projects	Any	Validated through survey	257
13	Sudhakar (2012)	CFSs in seven categories: communication factors, technical factors, organisational factors, environmental factors, product factors, team factors and project management factors	Any	Software developm ent projects	Theoretical	117
14	Els et al. (2012)	Appreciation by stakeholders, time, quality, cost	Any	Built environm ent	Validated through an opinion-based survey	3
15	Hwang & Lim (2013)	Budget, schedule, quality	Any	Singapore construc-tion projects	Validated through an opinion-based survey	96
16	Nguyen & Chovichie (2013)	Budget, schedule, quality, safety, technical performance, functionality, productivity, satisfaction, environmental sustainability, Information, conflict, litigation, dispute	Any	Construc-tion projects	Validated through survey	3
17	Gudienė et al. (2014)	CSFs	Any	Construc-tion projects in Lithuania	Theoretical	82

No.	Success Model	Success Criteria	Project Size	Project Type	Theoretical or Validated?	Number of Citations
18	Howsawi et al. (2014)	Success criteria are to be identified by the user at different levels of the model.	Any	Any	Validated through case application and external evaluation by field PMs	21
19	Gollner & Baumane-Vitolina (2016)	Project Management, Time and Budget, ERP System Quality, User Satisfaction and Economic Value.	Middle-sized	ERP projects	Validated through survey	7
20	Doskočil et al. (2016)	Earned value technique parameters, risk evaluation and quality.	Any	Any	Theoretical	3
21	Davis (2018)	Various criteria depending on the participant's perspective	Any	Any	Validated	6
22	Jankunaite & Belevicien (2019)	Time, cost, quality	Any	Internat-ional cultural projects	Theoretical	0
23	Langston (2013)	Scope, time, cost, risk	Any	Any	Validated through case study	21

This systematic review of all the previous success models is of high significance as it reveals the similarities and differences in the evaluation of project management performance as well as the assessment of project success in various types of projects and from different perspectives. Only a few studies have conducted such an extensive investigation although project success has been broadly scrutinised in the project management profession. As shown in Table 13, each model possesses different characteristics and most of them are applicable only on particular types of projects. Although some are relevant to any type of projects, an inconsistent use of criteria can be seen among most of the frameworks.

As mentioned earlier, not only the required inputs to the models are not clear, but also different stakeholders working in other locations and on different project sizes might have different interpretations of the criteria. Stakeholders have different perceptions of success criteria and factors and these influence whether a project is perceived as a success or failure (Davis, 2016; Davis, 2017; Davis, 2018; Guadix et al., 2016; Qureshi et al., 2009; Rodríguez-Segura et al., 2016; Scandelius & Cohen, 2016; Turner, 2009; Turner & Zolin, 2012). Thus, the model to be chosen should be able to consider all stakeholders views.

After an extensive review of the literature, the identified research gaps are as follows:

1. Most of the proposed models and frameworks fail to offer a set of success criteria that can be quantitatively measured.
2. Only a few models consider the different perceptions of the various stakeholders of the project. This problem runs deeper than that when a massive construction project with numerous parties and participants involved is the subject of investigation.
3. Most of the models employ an overwhelming number of criteria or success factors that make it tremendously hard to assess the performance at every stage of the project.
4. The majority of construction models are focused largely on the project's financial performance, which is simply the most convenient measuring and reporting factor. Over the last thirty years, the other non-financial variables have not received adequate attention from the researchers (Meng & Fenn, 2019).
5. The review of project success models demonstrate that researchers are struggling to find a cohesive performance index, especially when comparing a project with others. Due to the lack of a standardised and feasible measurement tool, most researchers perform case studies at one or two specific locations by asking qualified practitioners to determine the main criteria they believe to be the most important ones, or they provide them with a set of factors extracted from literature and ask

professionals to rate the CSFs accordingly. It means that no standard success criteria have been used in any construction projects to date (Meng & Fenn, 2019).

2.7 CONCLUDING REMARKS

As explained above, achieving project success in the construction industry can be a perplexing challenge. The amount of cost and time overruns, as well as project defects and rework, amplifies the need for a new approach that can be applied to any type of project, regardless of size and location. Most of the existing models and frameworks have shown deficiencies in the provision of a robust success measurement system.

In this chapter, the extensive body of literature in the field of project success, especially in the construction industry, has been critically reviewed, including every main project success model developed in the last 30 years (from 1989 to 2019). The success criteria utilised by the different models and the CSFs identified in multiple fields of construction projects are numerous. Over the years, researchers have provided several KPIs to evaluate the project performance, and most of them are explored in this chapter. Furthermore, this chapter identifies the research gaps in the context that they can be bridged via the testing of a model that utilises generic KPIs and success criteria applicable to all types of projects. The most recent model is considered best placed to meet this need. Langston's (2013) original model has been extended to include TBL and a complexity factor. Using this enhanced framework, one can overcome problems that might arise when applying the other previous models discussed in this section. This is because the 3D integration model is validated, can be applied to any type of project anywhere in the world and measures project delivery success quantitatively. This latter point is significant to practitioners and is the main problem with most of the other frameworks. The next chapter will discuss the research methods and plans to fully test and validate this approach.

CHAPTER 3: RESEARCH METHODS

3.1 THE PURPOSE OF THIS CHAPTER

This study examines a success model in the Australian construction industry called the 3D integration model (Langston, 2013; Ghanbaripour et al., 2017). The related literature has been discussed in the previous chapters. Firstly, the Australian construction industry and the issues surrounding this massive business were introduced. Second, the project success, its criteria and variables and also the key performance indicators used by organisations to assess the performance of their projects were explored. Finally, all of the main project success models that the researchers have developed over the past thirty years were critically evaluated and the research gap was subsequently found by comparing those with the model that this research aims to examine.

The previous systematic literature review employs a comprehensive and reproducible search strategy by reviewing all the project success models introduced in the literature. This method is adopted in order to demonstrate that the concept of effective project delivery success has yet to be agreed upon, so a perplexing challenge still exists among academics and practitioners to define when success is achieved in a project. Although several studies have made attempts to address this confusion, still no consensus on a consistent set of performance metrics or a practical project success model is formed. More importantly, an ability to measure success across different project types, size, location and date is limited only to the 3D integration model.

From this platform, the 3D integration model (now embedded within the project implement phase of *i3d3*) can be validated. This chapter describes that process.

3.2 RESEARCH QUESTIONS AND OBJECTIVES

The focus of this study is the Australian construction industry. It is the third largest employing sector, contributes significantly to the national economy and supports nearly all other sectors. Therefore, this study highlights the compelling need for an acceptable framework for the evaluation of construction project success, as delays in these significant and costly projects lead to a loss of prosperity for Australia.

The aim in this research is to develop a robust approach to the project Implement phase of *i3d3* based on earlier work and capable of assessing success for any type of project, and then test this approach to measuring PDS using real case studies provided by a major project management consultancy practice in Australia.

Based on the identified knowledge gap, the primary research question is:

> *Does the ranking of projects according to PDS provide useful insight for project management consultancy practice in Australia to systematically improve its implementation performance?*

This question has been continuously reformed over the course of the research process to represent the main requirement of the study. Its answer can validate the process taken. Reflecting and reformulating the research question is a key point of reference for determining the appropriateness of the decisions made at various points during the research (Flick, 2014).

Figure 28 shows a simple illustration of the 3D integration model (similar to Figure 25) that is to be used to answer the research question. In the process, insight into the behaviour of the six KPIs (value, efficiency, speed, innovation, complication and impact) is measured. Coupled with an assessment of TBL (as described in Figure 26) and an adjustment for complexity based on the CFC (as described in Figure 27), the delivery success of construction projects is computed as the PDS score converted to a scale of +100 to -100 and expressed in terms of its four critical success factors: cost (within budget), time (on schedule), scope (as specified) and risk (no surprises).

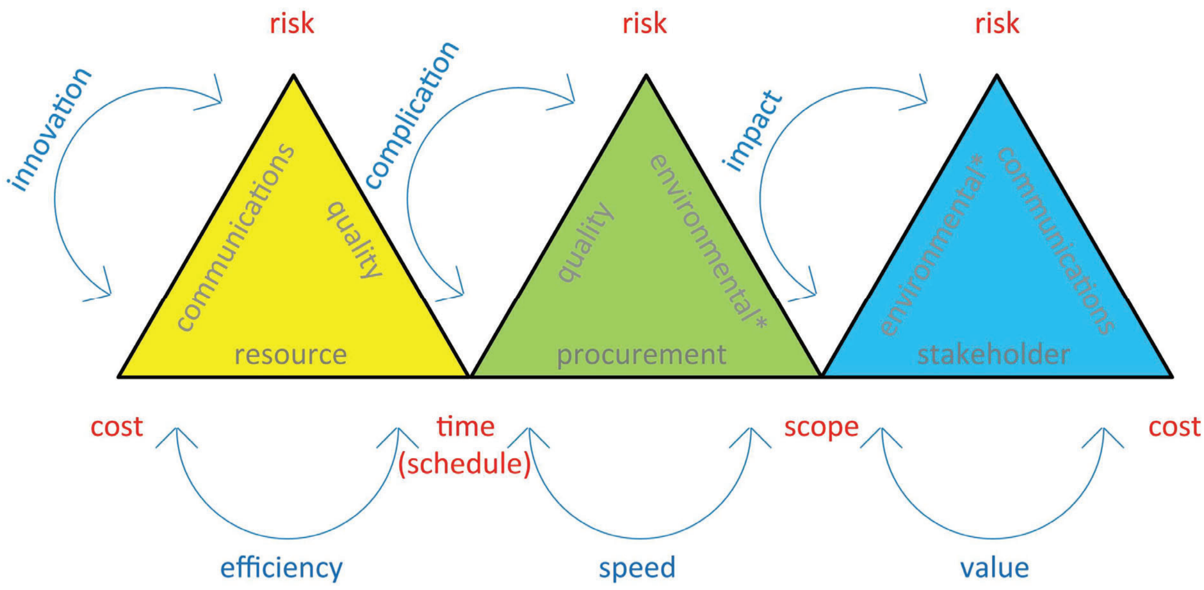


Figure 28. Summary of Model used to Calculate PDS

3.3 RESEARCH DESIGN

The research question determines the methodological strategy that needs to be put in place. This is a mixed-method approach by applying a triangulation of data collection from reviewing multiple case studies retrospectively.

Research can be divided into two distinct types: qualitative and quantitative, based on traditional schools of thought. The former focuses on terms and observations that reflect reality and seeks to characterise individuals in natural contexts. In comparison, the quantitative approach stems from a strong academic tradition that places considerable confidence in statistics reflecting viewpoints or concepts. The controversy over the relative virtues of both quantitative and qualitative methodologies has gained significant momentum over the years. While the exact constitution of the two methodologies differs somewhat from researcher to researcher or is described with varying degrees of precision, the basic antinomies and their practical implications for the conduct of the study are substantially agreed upon. Qualitative, as well as quantitative strategies, obviously have different strengths and weaknesses (Amaratunga et al., 2002). Through his research study, McGrath (1981) reveals that there are no perfect solutions, but only a set of compromises. This study utilises a mixed approach because it enables the researcher to use the strengths and minimise the drawbacks of each method (Johnson & Onwuegbuzie, 2004). This allows the researcher to respond to questions that cannot be addressed using other methodologies – in many cases using a mixed-method approach provides the best opportunity for addressing the research question (Leppink, 2017; Malina et al., 2011).

According to Johnson et al. (2007), a mixed-method approach is used when a researcher or team of researchers combine elements of qualitative and quantitative research approaches (for example, use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purpose of breadth and depth of understanding or corroboration (Johnson et al., 2007).

Mixed methods research constitutes a 'third wave' or 'movement' of study (Tashakkori & Teddlie, 2003) beside pure quantitative and qualitative mono or multi-methods. Built environmental research comprises cognitive, affective and behavioural elements. Strong qualitative or, more often, quantitative methodologies are used in current built environment research (Amaratunga et al., 2002). Several scholars have noted the growing complexity and evolution of project management research in recent decades (Kwak & Anbari, 2009; Sankaran et al., 2013; Söderlund, 2004; Turner et al., 2011). Turner et al. (2011) refers to the increasing sophistication and methodological rigour of project management studies as a result of a review of project management research areas, methodologies and citations published in three project management journals from 1987 to 2007.

Kwak & Anbari (2009) argue the project management research community needs to actively promote project management as an academic discipline through related management disciplines and concluded that project management is now a more applied and interdisciplinary field compared with other fields of management (Cameron et al., 2015). According to Jogulu & Pansiri (2011), adopting research designs that go beyond the conventional dominance of any one particular research technique, either quantitative or qualitative dichotomies, produces research outcomes of high standing. The use of mixed methods in project management research has increased marginally since 2004. However, it is not keeping pace with the use of mixed methods in other fields of management research (Cameron et al., 2015). Advantages of this method include the following (Almalki, 2016):

- One method may produce results that identify issues that need to be addressed by another method,
- One method may produce data to strengthen the data generated by another method,
- A method may be used to eliminate or neutralise differences in the results generated by another method, and
- the generated quantitative and qualitative data can be incorporated into a single broader database.

This methodology has been adapted in this research to benefit from the described strengths of mixed methods. This decision is endorsed by a study conducted by Jogulu & Pansiri (2011). Two management doctoral research projects are analysed in their research so that the benefits of mixed methods as the main research design could be demonstrated. They conclude that '*it is obvious that research using mixed methods can be employed to study an array of topics in the management discipline, with diverse research instruments such as replicating existing measurement tools in the literature as well as developing one's own questionnaire. Mixed methods allow and foster creativity amongst researchers in their research design, data gathering and data analysis. Most importantly, these research skills are invaluable for providing doctoral students who wish to take up academic roles in universities with adequate knowledge for effective teaching and supervisory skills. As scholars, we should at least, aim to have a minimum degree of knowledge and experience of quantitative and qualitative research methods*' (Jogulu & Pansiri, 2011, p.698).

3.3.1 SETTING THE SCENE

The 3D integration model is designed to set out a case for a way to compare and rank PDS for any project of any size, location or date. Master degree students at Bond University have been using this model as a method to calculate and forecast the progress of a hypothetical project called Utopia as part of one of their assignments. The author began investigating this topic a few years before he initiated his current PhD program. The author and his supervisor once expanded the 3D integration model to include an assessment of triple-bottom-line (TBL) performance and applied it, for the first time, to a real-life case study (Ghanbaripour et al., 2017). The case was a subway station megaproject. From the field data, the subway was viewed as unsuccessful, and the site project manager and representative of the consumer then verified the results. On the basis of the results from the study, a successful outcome was generated, which could have been done to improve project efficiency. The model provides an optimised profile that might be helpful in trying to get the project back on track after problems arose.

Nevertheless, they also decided to test the model in a completely different context, such as the construction sector in Australia, by gathering data from multiple case studies in order to achieve a detailed understanding of the model and its application in other types of infrastructure projects. This led to the initiation of this research. The research team at Bond University, introduced a more comprehensive model in 2018 called *i3d3*, which encompassed the 3D integration model in the middle of its three-phase success measurement procedure.

The *i3d3* philosophy is that there is a difference between project (product) success and project delivery success. It covers pre-implementation (design), implementation (deliver) and post-implementation (delight) phases, and recognises that projects should not be considered 'finished' at the time they are handed over. The success of each phase is judged by different groups of stakeholders, using different criteria – but there is a commonality across all three phases: namely financial, social, ethical and environmental consequences.

3.3.2 MULTIPLE CASE STUDY

As previously mentioned, the 3D integration model was tested in 2017 using a single case study with Professor Langston. But this single case merely demonstrated an idea; it did not validate the model itself. The researcher here has opted to use a multiple case study approach to validate the model in Australia, to provide a more in-depth understanding of its mechanisms and capability and strengthen the significance of the findings. The case studies from which the data are obtained from a large project management consultancy and represent completed construction projects across three Australian cities: Brisbane, Sydney and Melbourne.

Yin (2018) argues that there are four types of research design: single-case (holistic), single-case (embedded), multiple-case (holistic), and multiple-case (embedded). The single-case design is ideal for critical, extremely unusual, normal, revelatory or longitudinal (two different points in time). A potentially single-case design weakness could be that the researcher might notice that the scenario is not what is expected at the beginning of the study. When the researcher intends to present a persuasive argument for the analysis at hand, multiple-case design may be more appropriate A holistic case study has one analysis unit, but an embedded case study has two or more units of analysis. Therefore, a multiple-case study (holistic) review can be used to examine artefacts relating to the research question and the variables of this study (Neves, 2012).

So far as project success research is concerned, many researchers have been using this method to solidify their research results. For instance, Shenhar et al. (2001) develops a multi-dimensional framework in their research. Their project performance evaluation model was linked to strategic management and top-level decisions on project selection and initiation. Almahmoud et al. (2012) creates a Swiss Cheese Performance Management Framework that could allow project leaders to identify the root causes of any failures at the very early stage of the project delivery process, leading to a more successful project and effective performance management. They accomplish their research objective by analysing case studies in the building industry in Saudi Arabia. Scheuchner (2017) uses this method to analyse the approaches used by IT leaders to execute projects successfully. Likewise, Oputa (2017) analyses project managers' approaches towards the implementation of major infrastructure projects in the Nigerian oil and gas industry, from the viewpoint of owner and contractor organisations through multiple-case study research design. Melton (2018) undertakes a research project to examine project managers' perspectives on the effect of stakeholder management in relation to long-term project performance. In their analysis, an instrumental case study design offered a general overview for prioritising the involvement of different stakeholders, an assessment of the transparency on the purpose of projects and the role of various internal and external stakeholders across multiple phases in a project.

The multiple-case study technique aims to identify patterns that can either be similar (literal replication) or contrary but for predictable (theoretical replication) reasons (Yin, 2018). Multiple-case studies are assumed to be more rigorous than single-case studies since cross-case analyses allow for greater strength in the process of interpretation building and recognising the impact of background variables. In a multiple-case study approach, scenarios are analysed in their real-life conditions based on multiple sources of evidence, and it aims at generalising them into a theory (Groat & Wang, 2013; Sutrisna & Barrett, 2007).

3.3.3 TRIANGULATION

The triangulation methodology is also employed in this research, as it is claimed that, in order to address the challenges faced by construction project management research, a combination framework that acknowledges both ontological (referring to the metaphysical essence of being) and epistemological (referring to the philosophy of process or knowledge) viewpoints must be used. This method is assumed to be an appropriate tool in doing so (Blackwood et al., 1997; Holt & Faniran, 2000; Love et al., 2002).

According to Joslin & Müller (2016), research designs that are recognised within the research paradigm form the essence of the studies and influence the outcomes of the study. In addition, researchers too frequently adapt the research questions to the methodology they are comfortable with instead of adapting the research design to the questions (Williams & Vogt, 2011). This limits the diversity in research designs, resulting in repeatedly narrowly constructed studies with often predictable outcomes (Sankaran et al., 2013). A consequence of this strategy is the possibility of conducting research that not only yields predictable outcomes but also discovers fewer or less interesting phenomena. Triangulation may be an excellent solution to overcome the above risks, considering the suggestions for the need to more 'box-breaking' research made by Alvesson & Sandberg (2014).

This method of analysis is often used in project management studies. Shehu & Akintoye (2010) deploy triangulation to provide a profound insight into the major challenges confronting the application and implementation of construction project management and performed a pragmatic and theoretical analysis by triangulation using literature, an industrial questionnaire survey and semi-structured interviews. Within the UK construction industry and other project management fields, this work was conducted to examine and exploit the awareness of these challenges for the successful development and implementation of construction programs. A substantive theory of ties between policy, portfolio management and organisational alignment triggered by strategic portfolio implementation was developed through the data triangulation and case studies in the German construction sector by Kaiser et al. (2015). Nawi et al. (2012) conducted a study and analysed the CSFs important for optimising the convergence of design and construction practices, and summarised industry workshop guidelines for the critical success factors in the effective implementation of an integrated design team. In their research, the results of secondary (literary) and primary (industry workshop-based) data are combined through triangulation and then validated as an initiative for strengthening team collaboration in Malaysian Industrialised Building System projects. In the UAE, Khan (2014) uses a multiple-case research methodology and the data obtained is triangulated to determine the effect of national culture on the success of construction projects and to assess the causes for the success or failure of construction projects from a cultural perspective. Fulford & Standing (2014) triangulate interview results, project documents and public information to define collaboration variables and provide a basis for implementing a collaborative network approach to the Australian construction industry.

The term triangulation derives from trigonometry and geometry and defines the approach by calculating angles of the object in two other established places to determine the position of an individual (Clark, 1951; Joslin & Müller, 2016). The triangulation method, as described in social science research, uses multiple research techniques and/or measurements to resolve issues with bias and validity in social science research (Black, 1993; Love et al., 2002). It is also a method of validation or 'testing' of research results in itself (e.g. Nesan, 1997).

Denzin (2017) distinguishes:

- *data triangulation*, where data are collected at various stages or from several sources,
- *investigator triangulation*, where different researchers separately collect and analyse data on the same phenomenon and eventually compare results,
- *analytical triangulation*, where multiple methods of data collection and analysis are used, and
- *interdisciplinary triangulation*, where the research process is receiving inputs not only (for example) by psychology, but also by other disciplines such as economics, law and sociology (Love et al., 2002).

Based on the above classification, this study uses analytical triangulation and collected data from each case study using quantitative and qualitative methods.

3.4 RESEARCH PLAN

This research is focused on the evaluation of the project success across a dataset of construction projects in Australia to validate the adopted approach make a contribution to knowledge by providing a functional framework for the industry that practitioners can use to assess their performance and compare projects on a single scale. It is essential to determine what research plans are adopted before the study has been undertaken as this helps to gather data and samples as effectively as possible so that the question at hand is addressed (Rajasekar et al., 2013).

The research design section indicates how this objective could be accomplished. Various strategies are selected based on their effectiveness and suitability for carrying out this task. The data collection and interpretation methods are discussed in the following sections.

3.4.1 DATA COLLECTION

In order to gather the material for the analysis, the research question is looked at as a guide for the data collection procedure (Culbreath-Manly, 2016). This section outlines the measures taken to approach the participants, to collaborate and to operate the instruments. Such measures led to productive cooperation with the case study (collaborating) organisation, to the monitoring of requirements and to the implementation of quality assurance in data gathering (Jugdev, 2003; Yin, 2018). The phase of data collection began with a case study protocol, established to improve research reliability. The use of the case study technique strengthened the efficiency of analysis by providing specific instructions for the method of data collection to make sure the sample is consistent (Pemsel & Wiewiora, 2013; Yin, 2018).

The researcher reviewed several case studies to address the research question. This study plans to test the 3D integration model within *i3d3* using the quantitative data gathered, and then triangulate the findings with qualitative data to validate its performance. A collection of retrospective case studies is used to build a dataset suitable for analysis. For all this, one project management firm is chosen, which undertakes various types of infrastructure projects across Australia and has offices around the world. The data collection consists mostly of in-depth, face-to-face semi-structured and structured interviews with all the project managers involved in the surveyed projects, and also the organisation's director. Each project manager is asked to provide details on the projects they have previously managed and completed. In order to triangulate the findings, senior managers are interviewed at a separate meeting and asked to complete a questionnaire on the same projects. An overview of the study, estimates of time commitment and a description of study advantages are previously presented to the project and senior managers.

This process started once the researcher received the ethics approval and an agreement was made between the target organisation and Bond University to obtain permission to undertake the interviews and also to prevent the disclosure of the projects' information. Sufficient time for scheduling the meetings was needed. Both interviews and data gathering from those 40 projects lasted 27 months. The data gathered is considered extremely sensitive because it includes the cost, duration and collaborating organisation's performance throughout the years. That is why the identity of projects and collaborating organisation is be concealed.

A variety of methods are used to allow for more effective data collection at each interview, such as careful listening, examining the project files, exploring the project risks with the project managers, and elaborating on the survey questions. At the beginning of each interview, the participants were told that they could opt not to answer questions and that the meeting would be terminated at any point on request. No one called for an interview to be halted.

In this study, typical criteria regarding sample size are irrelevant since replication-logic and not sampling-logic is utilised (Yin, 2018). The target construction projects in this study are required to have been built in various parts of Australia and should possess the characteristics expected in a typical project. This information can include but is not limited to a clear scope statement, budget and duration reports, and a risk register. Regarding the qualitative data that is obtained from the PMs through interviews, there is no experience, age or educational requirements. However, all PMs should have been involved with the project during its life. Inclusion of 40 PMs fulfils the thematic saturation for a qualitative study that is considered, by other researchers, to be of an appropriate number for saturation as the point after which the collection of new data will not provide greater understanding on the subject being investigated (Case, 2017; Mason, 2010).

3.4.2 QUANTITATIVE: SURVEY QUESTIONNAIRE

The most popular method of data collection in research is the questionnaire, which helps researchers to collect information on knowledge, attitudes, opinions, behaviour, facts, etc. (Radhakrishna, 2007).

This approach is used commonly in construction management and project success studies. Belout & Gauvreau (2004) provide questionnaires to Canadian project managers for the purpose of evaluating the relationship between project performance and human resource management. A four-section survey is developed to collect input from researchers and industry experts in the USA by Nitithamyong & Skibniewski (2006), to identify the protentional factors that could affect the output of web-based project management systems in building projects.

Chen & Chen (2007) conduct a study to identify possible factors that are critical for partnership success. The opinion of the different stakeholders, including government employees, owners, designers and contractors, regarding building partnership factors that are crucial successors in Taiwan are sought and assessed through questionnaire surveys. Wu et al. (2017) use a five-point Likert survey questionnaire to identify the primary risks to success in the Chinese construction industry. In Vietnam, Nguyen & Hadikusumo (2018) create a seven-point Liker-scale questionnaire and ask more than 700 respondents to identify the impact of human resource management implementation on the success of the engineering, procurement and construction projects, and also human resource competence, job performance and the interrelationship between them.

The advantages and disadvantages of questionnaires with closed-ended questions are summarised below (Al Hasani, 2018; Creswell, John & Plano Clark, 2017):

Advantages:

- The answers can be quickly interpreted and compared.
- Figures, charting and tables can provide the results.
- Questions and responses can be standardised.

Disadvantages:

- There may be useful knowledge and observations missed because the respondents may not be able to articulate themselves fully.
- The researcher cannot always be assured that a respondent has understood a question or statement provided. In reality, the respondent may have misunderstood it.

In this study, the researcher made requests for interviews, to discuss the questionnaire with project managers, via e-mail to senior managers, and to set up one-hour meetings with each project manager. Some project managers have already quit the company and could not be approached. The researcher was included in all correspondences to track the process since the project managers had to recover details from the project files that they had previously completed. In certain situations, the project manager and the researcher had to sit in the meeting for more than an hour to gather all the relevant data from the archives, in particular on the expected and actual risks. Most of the meetings, however, took about an hour.

Each project manager received a form-based data sheet for setting out the details required. The first questionnaire was a one-sheet data collection questionnaire for the project and was filled out during the interviews to obtain the information needed for each case study. It asked for some general project details, and then the planned and actual scope, cost, time and risk values to calculate PDS. The various sections of this questionnaire are described below.

Project Manager:

The name, email and phone number of the project managers are requested in case further clarifications on the project data are required. Needless to say, as stated in the research ethics section, this information is kept confidential, and no one outside the research team and the organisation has access to it.

Project:

This section requested information about the project, such as the State in which the project was carried out, the owner, start and finish dates, project and contract type. Although such data will not be disclosed, the research team collect it as background since it may be useful for interpreting results and outliers. Also, such information can help the researcher in the analysis procedure to gain a better understanding of the dataset collection.

Project Type:

The collaborating organisation has managed numerous construction projects ranging from airports and railways to commercial buildings and small refurbishment projects. It is necessary for the researcher and the interviewee to know the type of project in order to select the best element of the project for the quantification of scope. Although it is irrelevant to the model since it is applicable to all types of projects, such information may be helpful when analysing the quality of the data.

Scope:

This part is one of the most challenging questions and requires more clarifications for the interviewees to obtain the right information. Literature has shown that scope management can have a significant impact on project success (Agarwal & Rathod, 2006; Cerezo-Narváez et al., 2016; Mirza et al., 2013; Ward, James A., 1995; Young, 1998) and it can be seen that in the PDS formula introduced by Langston (2013) that scope plays the most important part by being cubed in the numerator. The main element of the project or the most substantial factor affecting the project's cost and time is considered to be the scope of the project. For a building, then the planned and actual gross floor area (GFA) with the unit of m^2 are collected.

Time:

In the literature, the time of the project has many definitions. The maximum time allowed for the completion of all work, as outlined in the contract documents (Herbsman & Ellis 1990), shall be the project time. According to Chan (2001), it is the duration of building period from the date of site possession to project closure. In other words, the building timeframe is from site ownership to practical completion. Whitmore et al. (2008) state that the time duration of the project is as long as the project has been active.

In this study, when gathering the project data, the length of the construction life of the project, from the kick-off meeting to the last day of the closing phase, is considered. However, this length of time can change as the model calculates the ratio of actual value over planned, so if both values are based on the same start and finish points, then it would not matter what points in time are chosen. It could be measured in working hours or days, calendar weeks or months from contract commencement to completion as planned or achieved. It would make no difference.

Cost:

Cost may be measured as the contracted amount for the project and its final account after reconciliation. Again, it makes no difference what unit of currency is involved.

Risk:

Risk is measured as the square root of the sum of probability x impact (using a 1-3 scale) for all identified risks, both before commencement and upon completion. In the latter case, probability=3 (i.e. very likely) is assumed for all identified risk events, and actual impact is re-evaluated with the benefit of hindsight. This was another field where the researcher and the interviewee (project manager) needed much analysis into the files of the projects. The researcher and the interviewee checked the primary risk register that was created during the planning process to quantify the expected uncertainties of the project. In order to extract a list of actual risks, the risk documents, including the last risk register in the final project closure report, are reviewed. A list of the actual risks and impacts is then drawn up. In this case, the actual risk is calculated by assuming that each identified risk has a likelihood score of 3 (i.e. the likelihood was now certain). When a risk occurrence has little to no effect on the project, then the rating is 1, and a score of 3 at the other end of the scale implies that there has been a substantial impact. The risk level is calculated as the multiplication of probability (1-3) and impact (1-3), and these values are then averages across all risk events (1-9) before taking the square root of the mean. A 3×3 assessment matrix is applied during this process.

Customer Satisfaction:

Project managers are asked to rate customer satisfaction on a scale of 1 to 10, based only on their opinion and observations. This also may be used for background information to interpret findings.

Comments:

This is an open-ended question for the interviewee to comment on any major issues and risks of the project or the reasons in cases where massive variations have occurred between the planned and actual performance of the project.

3.4.3 QUALITATIVE: STRUCTURED QUESTIONNAIRE

As described earlier, this study adopts a hybrid methodology approach for analysis and data from each project are collected from the project itself (quantitative) and individuals (qualitative). This methodology allows researchers to use two or more forms of methods for data collection and interpretation (Yin, 2018). As part of the triangulation method, qualitative data gathering provides cross-validation between data sources and relevant study results. The researcher compares different sources, contexts and strategies in order to identify patterns in the data to see if the trend tends to reappear (Cooper, 2011; Schumacher & McMillan, 2006). This means that the argument is presented from multiple viewpoints and does not rely on a single source of information or method of data gathering. It can be achieved in two ways, either simultaneous or sequential. '*Concurrent mixed-method data collection strategies are employed to validate one form of data with the other form, to transform the data for comparison, or to address different types of questions*' (Ivankova et al., 2007, p.118). For many cases, the same people provide qualitative as well as quantitative data to make it easier to compare both (Driscoll et al., 2007). Sequential mixed-methods of data gathering approaches provide a collection of data in an ongoing process by which data gathered in one step relate to the information obtained in the next. '*Data were collected in these designs to provide more data about results from the earlier phase of data collection and analysis, to select participants who can best provide that data, or to generalise findings by verifying and augmenting study results from members of a defined population*' (Ivankova et al., 2007, p.121). In sequential schemes, the first round quantitative data collection may use statistical methods to describe what results should be expanded over the next stage (Driscoll et al., 2007). For this study, concurrent data collection is used. It should be noted that qualitative data analysis is one of the most difficult parts of academic research. In addition, the studies are faced with the dilemma of pleasing the 'quantitative-researchers', who firmly contend that quantitative analysis is the only credible method, and the 'case-study critics'. Quantitative analysis believers and most case study critics should feel confident that the researcher uses systematic questionnaires to gather data efficiently (Rwelamila, 2007).

Qualitative data may be obtained in a variety of forms. In this research, questionnaire-based interviews are performed with senior managers. First, a questionnaire named 'Performance Assessment Review' is purposely developed based on the *PMBOK® Guide* 6th Edition (PMI, 2017) that includes 20 close-ended statements, requiring answers on a 5-point Likert scale varying from ‘strongly agree’ to ‘strongly disagree’ with either positive or negative polarity, asking senior managers about their experiences during and after the project. The questionnaire gathers information as to whether the senior manager thought, for instance, the scope slipped unintentionally, or if the date of the scheduled beginning of the project was considerably different from the actual start of the project. Interviews allow the researcher to gather accurate and relevant qualitative evidence (Creswell & Creswell, 2017).

In studies on project success, interviews have been widely employed as the main data collection strategy (Bryde & Robinson, 2005; Hughes et al., 2004; Rolstadås et al., 2014; Wateridge, 1998). This technique is utilised by researchers to study project performance in the construction sector. Using this approach, Phua & Rowlinson (2004) established significant construction success factors in Hong Kong. Songer & Molenaar (1997) interview members of the federal government to investigate the appropriateness of a design-build implementation method for effective building developments in the United States. Toor & Ogunlana (2009) catch the understanding of construction professionals through 34 interviews on the CSFs of large-scale construction projects in Thailand. Lim & Mohamed (2000) run a series of unstructured interviews and discuss the possible causes for repeated building challenges that hinder the completion of such projects. Frödell et al. (2008) carry out multiple interviews in Sweden in order to explore stakeholders' expectations towards the performance of projects and to assess efficiency in building projects within established client organisations.

The interview conducted for research may be either structured or semi-structured (Odoh & Chinedum, 2014). The degree to which the interviewer directs the conversation and the extent of the answers from the participants differ. Interview styles involve face-to-face interviews, collaborative interviews and focus groups (Denscombe, 2014), with qualitative studies typically preferring a face-to-face interview style (Al Hasani, 2018; Creswell & Clark, 2017; Fontana & Frey, 1994; Irvine et al., 2013; Knox & Burkard, 2009; Oltmann, 2016; Ryan et al., 2009).

The advantages and disadvantages of interviews as a research method, include the following (Al Hasani, 2018; Creswell & Creswell, 2017; Denscombe, 2014):

Advantages:

- The research will typically get a decent rate of response.
- As an interviewer, the investigator can influence the interview.
- Interviewer or participant may require further clarification of the meanings.
- The investigator would be able to collect further information in fine detail.

Disadvantages:

- Interpretation of details from interviews can be time-consuming.
- Researchers might not receive standard answers.
- Data obtained from the responses of the interviewees may be influenced by interviewer's level of communications skills (or a lack of expertise).
- The interview may pause or postpone the meeting because of the recording process.
- Interviewees may find the interview an infringement of privacy and/or may cover up details.
- Meetings may be expensive and/or time-consuming whether the interviewees stay somewhere far out or hard to reach.

Interviews are typically completed at the participant’s workplace. The method used by the researcher to ensure the protection of participants' privacy and maintain their willingness in continuing the meeting is to explicitly notify participants of the intent, goals, and the usage of findings and anticipated outcomes of the study. The investigator advises respondents that they could, at any point, reject or leave the meeting (Dustman et al., 2014). From the outset, the researcher tells participants that ethical considerations are inculcated in any study initiative and they are informed of these restrictions and expectations by the researcher (Herr &

Anderson, 2014). The framework for exploratory study interviews allows participants to be informed of what was going on so that the procedure was open (Dustman et al., 2014; Starns, 2019).

Capturing the perception of the participants and the way that they observe and make sense of a situation is the main objective of qualitative research (Thompson, 2009). This phenomenon, in this study, is taken as the performance of the PMs from their senior managers' perspective. *PMBOK® Guide* 6th Edition (PMI, 2017) provides a solid basis and detailed description of the project management process (embedded in its 10 knowledge areas) that should be practised to increase the chance of achieving project success.

Therefore, proposing high-level statements that support each knowledge area is used to assess a PM's performance. These questions are thoroughly explained in this section. The obtained responses (PAR scores) underpin the research aim by contributing to the achievement of Objective 5 of the research, where the PDS and PAR scores are correlated to fulfil part of the triangulation process. General demographics of the senior managers are shown in Table 14.

Table 14. General Characteristics of the Qualitative Survey Respondents

General Demographics	Groups	Frequency	Per cent
Educational	Bachelor	8	61.5
	Master	5	38.5
	PhD	-	0.0
Age	20-29 years	1	7.7
	30-39 years	3	23.0
	40-49 years	5	38.5
	50-59 years	3	23.1
	60+ years	1	7.7
Occupation	Senior Manager	11	85.0
	Director	2	15.0
	PMO Lead	-	0.0
Experience	1-5 years	-	0.0
	5-10 years	3	23.1
	10-15 years	2	15.4
	15-20 years	6	46.1
	20+ years	2	15.4

This questionnaire (see Appendix 3) comprises two high-level statements from each of the ten knowledge areas in the *PMBOK® Guide* 6th Edition (PMI, 2017). This gives a total of 20 questions. Each question is explained below.

Project Integration Management:

A. *The project manager actively managed both sponsor and end-user expectations of benefit realisation.*

The response to this statement reveals how the overall goals and objectives of the projects were managed correctly. The literature shows that the priorities of the involved parties will have to be addressed (Haferkorn, 2018). This is essential in projects as the Strategic Forum for Construction (2003) suggests creating a client support team to manage client and end-user requirements from the very beginning and even beyond the project closure (i.e. the end of the duration of liability for defects). The support team functions as a central place for collaboration between end-users and the project and is working as specialists to effectively evaluate and, if necessary, fulfil expectations, thereby leading to an understanding of where and why objectives such as cost, time, sustainability, etc. could not be accomplished (Izam et al., 2013). As one of these roles is highly important, the sponsor is responsible for multiple activities spanning the entire process of projects and the continuous monitoring of benefit realisation, and it is the responsibility of the project manager to handle these demands (Bryde, 2008; Hall et al., 2003; Kliem & Ludin, 1992; Morris & Hough, 1987; Turner, 1999).

B. *The planned and actual performance was assessed regularly using earned value management.*

In order to assess how dedicated the project team are to project control and tracking success within the area of project integration management, this statement is included in the questionnaire. For the lifetime of the project, the project manager is responsible for managing the project network and measuring the actual cost, time and quality discrepancies from the plan (Blackburn, 2002). The project manager relies heavily on a consistent tracking system to report on projects challenges promptly, whether actual or potential (Cheung et al., 2004). It can be achieved through many strategies, such as project performance analysis, KPIs, using stochastic S-curves, earned value management, etc. (Barraza et al., 2000; Cheung et al., 2004; Crane et al., 1999). Once a project approaches the execution stage, actual progress is documented and measured against the expectations. The project may not be entirely carried out along with plans and expectations due to numerous unpredictable factors. Therefore, management should continuously and consistently be advised whether progress is advancing and that accurate assessment of the effect of each site occurrence on available resources and potential activities of each project is made (Ahuja & Thiruvengadam, 2004). Project performance evaluation can be conducted by comparing the most likely budget and duration values collected from actual progress from the respective probability distributions with the actual data and cumulative costs of the project (Barraza et al., 2000). In this regard, earned value management as a common approach can be extended to all types of projects to identify any early-stage deviations in the schedule (Fleming & Koppelman, 2002; Khan, 2006; Wanner, 2013).

Project Scope Management:

C. *Inadvertent scope creep did not occur or lead to the adjustment of time, cost or risk baselines.*

Inadvertent scope creep takes place when the project is gradually and unintentionally outgrowing, and when the exact cause and consequences of the alterations are very hard to trace (Sindi, 2018). This can happen for a wide range of reasons such as weak initial requirements analysis, inability to say no to a client, no structured change evaluation and approval processes that give the project participants the feeling that a minor change is not important (Turk, 2010). The project manager and team should correctly interpret the project's outcomes, evaluate the customer's expectations and determine the scope of the work precisely (Sindi, 2018). This question, therefore, inquires senior managers' opinion on the effort the project manager made to avoid scope creep to increase the likelihood of overall project success.

D. New ideas were routinely investigated and implemented by the project team.

To ensure successful project outcomes, the project team must develop and explore new ideas constantly across the entire project as well as improving the regular working methods (Izam et al., 2013; Jørgensen & Emmitt, 2009; Strategic Forum for Construction, 2003). A 'no blame' mentality is required by project managers to incorporate new ideas and evaluate them (Dulaimi et al., 2002). While construction companies do not typically evolve quickly over time and are reluctant to change (Ozorhon, 2013), this question asks the senior managers' opinions on the project team's level of flexibility and openness to change and new initiatives. According to Dulaimi et al. (2005), construction companies should promote project innovation by creating an effective organisational atmosphere to promote creativity by fostering a culture suitable to supporting and encouraging the role of the project manager as a creativity advocate. They also state that creative methods could increase organisational performance and provide construction firms with long-term benefits.

Project Schedule Management:

E. When needed, additional resources were applied in a timely manner to stay on track.

The project manager should be first and foremost a trouble-shooter in projects that too often change. They should be able to spot discrepancies and propose solutions to keep the project on track (De Meyer et al., 2002). If indicators signify a variation between the planned and actual performance, management should use recourses with a priority for activities that lie on the critical path (Leemann, 2002). In order to balance the constraints, in particular, three critical baselines, these trade-offs are unavoidably required. For example, by adding more money, a job can be done very quickly, but if one is prepared to sacrifice quality, then one will have to pay more. Such considerations on trade-offs arise both during the project planning and project implementation processes (Koelmans, 2004; Maylor, 2001). This question asks about the effective use of scheduling management strategies to keep the project on track throughout the work.

F. *There were no delays to critical tasks that impacted on the agreed project completion date.*

While delays prevail in most construction projects, be it simple or complex (Salunkhe & Patil, 2014), project managers should preferably prevent such detrimental factors. The delay in construction is seen as a chronic challenge in the building industry, and in terms of time, cost and efficiency, it has a negative effect on project performance. Previous studies indicate that the failure of any project is primarily linked to the problems with the project performance (contractor, owner, etc.), which leads to overrun in project cost and time for completion (Alwi & Hampson, 2003; Assaf & Al-Hejji, 2006; Majid & McCaffer, 1998; Salunkhe & Patil, 2014). This question asks the senior managers whether any internal project-related delay occurred in the projects they were involved with. Such delays may have affected the starting date, duration or even have suspended the project (Arditi et al., 2017). There might be extraordinary events that apply.

Project Cost Management:

G. *Savings were found and used to reduce the contracted project cost.*

Improved and more advanced project management increase cost-effectiveness contributing to more budget savings in projects (Yazici, 2009). Cost management skills have demonstrated to be one of the main project management competencies to empower the project to achieve more favourable outcomes (Attakora-Amaniampong, 2016). Kujawski & Alvaro (2003) argue that today's traditional probabilistic cost analysis implies an ‘ideal’ project in which, if a cost factor becomes low, savings are transferred to where they are required. Needless to say, in the modern world, ‘money allocated is money spent’ (the MAIMS principle) and cost underruns are seldom possible to protect the project against cost overruns. In this regard, the questionnaire debates whether or not any incentives were made to ensure that project cost efficiency remains on-track.

H. *The number of variations on this project did not result in cost increases above the planned contingency.*

This question is about the effectiveness of cost control activities in projects. As a primary task for the project manager and since many variables are involved, the cost management process is often followed by the challenge of obtaining an accurate estimated cost forecast, successful cost analysis of the work in progress and successful post-project cost analysis. This leads to two thematic issues that managers usually face. Firstly, the need for thorough cost planning that assists in preparing a fair price estimate before the project begins. Secondly, cost efficiency during implementation should be actively monitored to meet or outperform the expected target (Goh, 2005). This question, therefore, includes almost all dimensions of cost control that the project managers should have taken into account to execute the project within budget.

Project Quality Management:

I. *The quality standard achieved for all deliverables was high with few, if any, defects requiring rectification.*

Incompetent management of the quality resulting in defects that are required to be addressed and redone can negatively impact construction projects' progress and success (Love, 2002). This question asks the level of consistency in quality control procedures in each project that may have impacted the success of the project, as shown by literature. Quality assurance mechanisms must be in place to achieve low-defect or no-defect outcomes. They don't happen by accident.

J. *There were no safety concerns or injuries recorded during project delivery.*

In regards to providing workers with a secure work environment, this question seeks details about the safety processes in projects undertaken by the project management team. Researchers and professionals have discovered that the main determinant of progress in most projects, irrespective of the outcomes of the other classical metrics, may be safety performance (Hughes et al., 2004). It is asked because in many projects, sadly, investments need to be prioritised and could be in conflict with scarce resources (Wanberg et al., 2013). Hinze & Parker (1978), for instance, gather empirical evidence to show a decrease in safety efficiency as the time pressure escalates. Various practical and theoretical models such as those discussed in Mitropoulos et al. (2005) support this statement. Moreover, Hallowell (2011) notices that investments in sub-optimal protection can result in higher safety accident rates and losses (Wanberg et al., 2013). Safety is being addressed as part of quality management in this questionnaire as a mix of values and practices of safety and quality management drawn on the similarities between these two management concepts to develop a common framework of 'synergistic' management to maximise safety and quality (Loushine et al., 2006). Both systems are identical and therefore, can be combined. Even Sommerkamp (1994) claims that the implementation of a safety initiative within an organisation is no different than the introduction of a quality measure. The combination of safety and quality offers a more holistic path for academia to encourage improvements in safety. Several authorities take a systemic view of the simultaneous enhancement of quality and health as a function of total quality management (Wanberg et al., 2013).

Project Resource Management:

K. *There were no delays in the commencement of key external contracts.*

Since the various tasks and the technology involved in construction projects makes them relatively complicated and distinguished, outsourcing is needed, and the project success is to some degree linked to the degree of collaboration between participating entities and the competence of the project resource management manager (Ronchi, 2006). Since subcontractors undertake huge chunks (approx. 85%) of all construction industry activities, it relies in great numbers on subcontractors' productivity (Mbachu, 2008) to execute the project within schedule, quality and costs targets. Therefore, this question is raised to comprehend the extent of competence of resource management engaged in project implementation in each target project.

L. The project team worked well together under effective leadership.

This question is raised because the project manager interacts closely with the project team in construction projects. This requires project managers to be capable of successfully and consistently handling disagreements to establish good ties and ensuring that their projects remain progressive (Sunindijo et al., 2007). Productive project managers understand people's values, and they acknowledge that there would be no project in the first place without people. They also agree that workers play a vital role in the delivery of a quality project within the budget and on time (Bubshait & Farooq, 1999). The project managers must lead their colleagues within the internal organisation, which requires them to possess effective communication skills to support project personnel to successfully accomplish project objectives (Lewis, 1998; Loo, 1996).

Project Communications Management:

M. All project data were digital and securely maintained and managed by the team.

Construction projects produce, process and store large amounts of real-time information before and after building on site (Craig & Sommerville, 2006). Construction activities are shrouded in information, and strategic planning of such projects requires effective communications management and information systems to facilitate bi-directional data entry, pattern recognition, dissemination and functional access. The flow of project information among stakeholders, many of whom have various interests and expectations, is critical to the functioning of any large construction project (Faniran et al., 2001). The growing clamour for meeting the increasingly challenging needs of the client and improving project performance motivates the construction industry keep moving towards highly integrated project teams where project stakeholders have immediate access to all project information through the use of information management systems (Moore & Dainty, 1999).

N. *Key stakeholders were provided with open and honest information concerning project performance.*

Communications management seems to have a direct relationship with project stakeholder management, according to (Demirkesen & Ozorhon, 2017). Efficient communication management requires collaboration with stakeholders (Baccarini et al., 2004). Information, response and engagement of stakeholders are rather critical to communication on corporate social responsibility (Morsing & Schultz, 2006). Communication is key to handling and successfully managing crisis situations among stakeholders (Ulmer, 2001). Improved communication contributes to improved project performance and project success; therefore this question asks the transparency level of communication in each project in notifying stakeholders with project information (Chang & Shen, 2009).

Project Risk Management:

O. *Expected risk was reconciled against actual risk at the conclusion of the project.*

At the time they come into existence, construction projects are threatened by risks (Schieg, 2006) and are seen as being at higher risks comparing to other types of projects because of the involvement of several contracting parties, including owners, contractors and designers (El-Sayegh, 2008). In construction projects, there are various risks and uncertainties. This not only prevents completion of projects within budget but also jeopardises the quality, safety and operational requirements (Öztaş & Ökmen, 2005). Since the primary objective of project risk management is to identify, analyse and control the risk for project success (Lee et al., 2009), this question is raised regarding the specific degree of consideration the project management team devoted to risk monitoring and control across the project. The relevance of this project success question is that substantial attention has been devoted to risk management in project management literature as well. Schieg (2006) supports this concern and highlights the importance of risk assessment through risk reports because risk management can help prevent failure during the closing stage. Furthermore, project management associations and their bodies of knowledge claim that the risk is critical to the success of the project. Zwikael & Ahn

(2011) demonstrate that even moderate risk planning levels would be sufficient to reduce the adverse impacts of risk on project success. However, multiple authors argue that in regular projects, and even in large and complex projects, risk management practices are still rarely used, and therefore a gap in the profession is identified (Carvalho & Rabechini, 2015; Dvir et al., 2003; Ibbs & Kwak, 2000; Zwikael & Globerson, 2006).

P. Positive risks were considered and embraced by the project team.

Project managers spend a great deal of time and effort on the mitigation and management of risks that would negatively affect the project, but as the literature has already shown, enhancing, embracing and maximising positive risks can have a significant effect on the likelihood of success in the projects (Perrenoud et al., 2017). The responses to harmful risks, in general, include avoidance, transfer, mitigation and acceptance of risk, and reactions to beneficial risk include exploitation, sharing, enhancement and acceptance, according to Perrenoud et al. (2017) and PMI (2017). The practice of maximising the overall effect of beneficial risks is significant, and the increased focus in the literature is not only on the inability to identify loss-causing risks but also on the failure to identify opportunistic events and the effect of non-identification of positive risks is equivalent to the impact of non-identification of adverse risks (Renault & Agumba, 2016).

Project Procurement Management:

Q. Suppliers and sub-contractors were satisfied with the amount and timing of remuneration for their services.

In a construction project, the primary players are the owner, the contracting company and the subcontractors, where each player has a different contract, but all participants have the same aim of achieving success. The results of the project are highly dependent on the level of the general and subcontractor management within the boundaries of a given project (Lee et al., 2018). The significance of subcontracting has long been acknowledged for the success of building projects (Dainty et al., 2001; Gray & Flanagan, 1989). Proctor (1996) emphasises that the general contractor is ultimately responsible for the success of a project, but subcontractors also play a major role since they are actually responsible for the implementation of the project. This question concerns the financial difficulties that could have affected the subcontractors and consequently, the project success (Eom et al., 2008; Eriksson & Westerberg, 2011).

R. There were no litigation or alternate dispute resolution procedures required.

Disputes arise in construction projects as long as people with different perspectives, desires and viewpoints are involved. In the construction process, three particularly annoying factors of disputes are unclear contract documents, competitive and oppositional attitudes and significantly different perceptions of fairness among participants (Spittler & Jentzen, 1992). The question is whether there were any occasions in which dispute resolution or even litigation was required.

Project Stakeholder Management:

S. Lessons learned from the project were formally recorded and discussed by the team.

Experience is acquired, and lessons are learned during construction projects. Over time, construction professionals have the chance to accumulate a wealth of knowledge, some of which is learned at large human or financial expenses. This question asks senior managers how much of this hard-earned knowledge is adequately documented, reviewed and discussed by the project team (Kartam, 1996). The lessons learned include communicating the experience from the various stages and phases of a project that went according to plan, the parts that could be improved and strategies to tackle these issues before proceeding towards the next phase (Jugdev, 2012). This can contribute to the success of projects, enhance customer satisfaction (Kotnour, 1999) and help participants gain knowledge of successful and failing practises (Busby, 1999). If properly utilised, lessons learned can provide a market advantage. They often overlap with wider areas of knowledge management and organisational learning that encourage creativity depending on the absorption abilities of the organisation (Cohen & Levinthal, 1990). In construction projects, it has been demonstrated that the main reasons for the lessons learned are: (1) to learn from similar projects to avoid making the same mistakes and ensuring recurring successes, (2) to provide a competitive advantage over other companies, and (3) to learn lessons for consecutive phases of ongoing projects (Carrillo et al., 2013).

T. *The sponsor was very satisfied with the quality of project management services.*

Studies have repeatedly shown that the strong support of top management, especially the sponsor, is a decisive factor in producing successful outcomes in projects (Crawford et al., 2008; Englund & Bucero, 2007). In addition to recognising this, successful managers are able to do everything that is required to ensure that their senior partners understand and fulfil this support role (Cooke-Davies, 2005). This question forms a check against a similar request by the project manager in charge.

3.5 ETHICAL CONSIDERATIONS

The primary issue with the research is that the company involved in this study is concerned that during or after the study, the identities of project managers and projects might be compromised. According to Vainio (2013), apart from ethical reasons, confidentiality is in any case important in undertaking qualitative research of a high standard. Anonymity in practice means that details about the identity of the respondents (names, ethnicity, ethnic origin, age, occupation, location, etc.) should be eliminated from the final research reports (Vainio, 2013). This was clarified by an introductory declaration in this research, specifying that participation in this research is entirely voluntary and there are no known or anticipated risks to your involvement. Data collection takes place under supervision in your office. The identity of your firm and your individual projects are kept anonymous and described in generic terms only. Once the research is complete, you are welcome to request a digital copy of the work. The raw data collected is kept in a secure place for 5 years and then appropriately destroyed.

Confidentiality requires not sharing information received by research participants with others and communicating results in such a way that research participants cannot be identified (through anonymisation), according to (Wiles et al., 2008).

It is necessary to ensure that proper planning and ethical standards are followed in order to prevent unnecessary study dilemmas, such as the feeling that their physical and mental wellbeing is in some way compromised (Cacciattolo, 2015). There are many reasons for adherence to ethical principles in science, according to the following (Resnik, 2011):

- Norms support research goals, including knowledge, honesty and error prevention.
- Ethical principles promote values, such as trust, transparency, mutual responsibility and justice that are essential to collaborative activities.
- Many of the ethical guidelines help ensure researchers are kept accountable to the public.
- Research's ethical principles also lead to public research support.
- Many of the research norms uphold a number of other essential moral and social values, including corporate responsibility, human rights, animal protection, respect for the law and health and safety.

An ethics application was officially made for this study, and it was appropriately reviewed and approved by the Bond University Human Research Ethics Committee (BUHREC) well before any interview was carried out, or any project manager was contacted. The approval number is 16014.

In this study, only data with regards to the performance of the projects, such as cost, time, scope and risk, and also data from senior manager professional experience and observations are gathered. This approach does not give rise to emotional and psychological harm. The sample is in no way viewed as vulnerable since no respondent can be personally and directly harmed through their involvement (Moore, 2017).

3.6 CONCLUDING REMARKS

This chapter addresses the methodological approach used in this research study, which consists of mixed-method (i.e. qualitative and quantitative) research design, multiple-case study strategy and triangulation. The quantitative method involves reviewing project data from multiple case studies, where in-depth interviews with project managers are conducted, in addition to collecting information on the main constraints of scope, time, cost and risk for each project through the investigation of archival documents, contracts and final reports. The results of the first round of project manager interviews are the completed questionnaires on the main elements of the project needed to calculate the PDS scores. The second round held with senior managers is intended to obtain the PAR score. The results of both scores and the correlation between them are discussed in detail in Chapters 4 and 5. Finally, this chapter considers the limitations of the study and the ethical considerations that are taken into account in the data collection process.

CHAPTER 4: FINDINGS

4.1 THE PURPOSE OF THIS CHAPTER

In the previous chapter, the research objectives, questions and methodology were thoroughly discussed. Also, the two instruments that were used to obtain the required data were introduced and described. In that chapter, the ethical implications of this study were explained too. This chapter showcases the findings from the multiple case studies investigated throughout the research. All the parameters calculated by the model, such as the six KPIs (value, efficiency, speed, innovation, complication and impact), PDS score and PAR score are presented as well as some information about the type of the project, the contract under which the target organisation has undertaken the project and also the client's sector is provided. In line with the purpose of the research, which is examining the 3D integration model, in this chapter, the results from the quantitative and qualitative data collected from the case studies are triangulated, and the correlation between the projects' ranking based on the PDS scores and the PAR score is measured.

4.2 DATA ANALYSIS

In this study, first, descriptive statistics are used to explain the general characteristics of the case study projects such as the project and contract types in order to provide a holistic overview of the target projects. Descriptive statistics are useful for organising and summarising data, especially for describing smaller populations being studied (Singleton et al., 2005).

SAS ® 9.4 is used for all the statistical analysis. In order to measure the accuracy of PAR in reflecting PDS, a paired t-test is undertaken. For the purpose of precision test, linear regression is then conducted. The adjusted R-square is regarded as a precision measure. However, the confidence limits of both regression parameters and prediction indicate the degree of precision. Also, the bootstrapping method is used to measure the reliability of the model.

Accuracy and Precision:

Accuracy is the quality of the data to represent the desired population parameter. On the other hand, precision is how well and precisely the data can show its parameter, whether it is accurate or not. In this study, therefore, accurate and precise data is desirable. Imprecision could be managed by an external parameter, which in our case is the mean difference between PDS and PAR. This parameter is assumed to be a fixed one that does not change significantly from sample to sample. In this regard, inaccuracy can be managed through the use of a large sample size, which is not the case with our data.

Since this study involves subject-specific analysis (each project), the paired t-test is used to assess the accuracy of PAR to express PDS (and vice versa). This technique measures the mean difference between the PAR and the PDS of the sample projects estimated at 76.03. In other words, the inaccuracy parameter of the PAR to represent the PDS is 76.03 (in units of measurement, which is per cent).

The regression analysis is used to measure the precision, as it is desired to measure the relationship between the two data sets. The closer the scatter is to the regression line, the higher the precision is. Precision is gauged here as R-square, 55%. This means that PAR could express the PDS with an average accuracy of 55% for each project. Adjusted R-square takes into account the complexity of the model. More complex models (in terms of the number of estimated model parameters) have a lower adjusted R-square, as they may be exposed to higher estimation errors.

Reliability:

Reliability in regression is another term of validity. This means that the regression parameter should be reliable enough to be consistent across different samples of the same population.

Thus, in order to determine whether the regression model is valid enough, there are different tests that can be carried out considering the size of the sample and the nature of the data:

1. Jackknife cross-validation (Leave one out)
2. Leave-p-out-cross-validation (LpO CV)
3. k-fold cross-validation
4. Monte Carlo cross-validation
5. Bootstrapping

Among the mentioned methods, Jackknife has the lowest power as it only estimates the model using n-1 sample. The second, third, and the fourth methods need a larger sample size, as they use a significant part of the sample for validation (minimum of 30%). In our case, bootstrapping (relies on random sampling with replacement) may be the best choice. However, this method is also susceptible to sample size. In bootstrapping, the software creates at least 1000 samples by randomly drawing the data from the main sample with replacement and then estimates the model parameters based on the obtained samples. If the estimated parameters from the original sample have an insignificant difference from the bootstrapped estimates, then the model would be reliable.

Correlation Method:

Relationships between the KPIs and also, between KPIs and PDSs are first assessed visually using scatter plots. The scatter plot shows the pattern of the relationship, so it can be determined whether the relationship is linear or nonlinear. As the relationships are linear for all the assessed relationships, Pearson's correlation coefficient is used to measure the relationships. The higher the correlation coefficient obtained, the stronger is the relationship. The difference between correlation coefficients shows whether successful and unsuccessful projects have different KPI relationships or not. Finally, the estimated confidence limits of the linear parameters (shades) and confidence limits of the prediction (parallel lines) are presented on scatter plots.

4.3 CASE STUDY DEMOGRAPHICS

This research explores 40 projects undertaken across Australia. More than 42% of the projects are educational, commercial, residential and healthcare projects, and the remainder are carried out to renovate, refurbish or extend existing buildings or facilities. Various types of contracts are regulated case study projects, but a majority (38%) are under traditional contracts, while lump-sum contracts accounted for 23% of the projects. In addition, 40% of projects are funded by government, while 60% are funded by the private sector.

Case study projects were from varying sizes too. The size of the project can be calculated in many ways, using a range of parameters such as cost, duration, code lines, project type, and contribution (Boehm et al., 2005; Koch, 2005). However, there are no uniform parameters for project size determination (Schalken et al., 2005). The majority of case study projects (43%) belong to the range category of under $10 million in terms of actual cost at the completion stage. At the high end, the largest project was completed with an actual cost of $517,000,000. Figure 29 provides a visual representation of the actual costs.

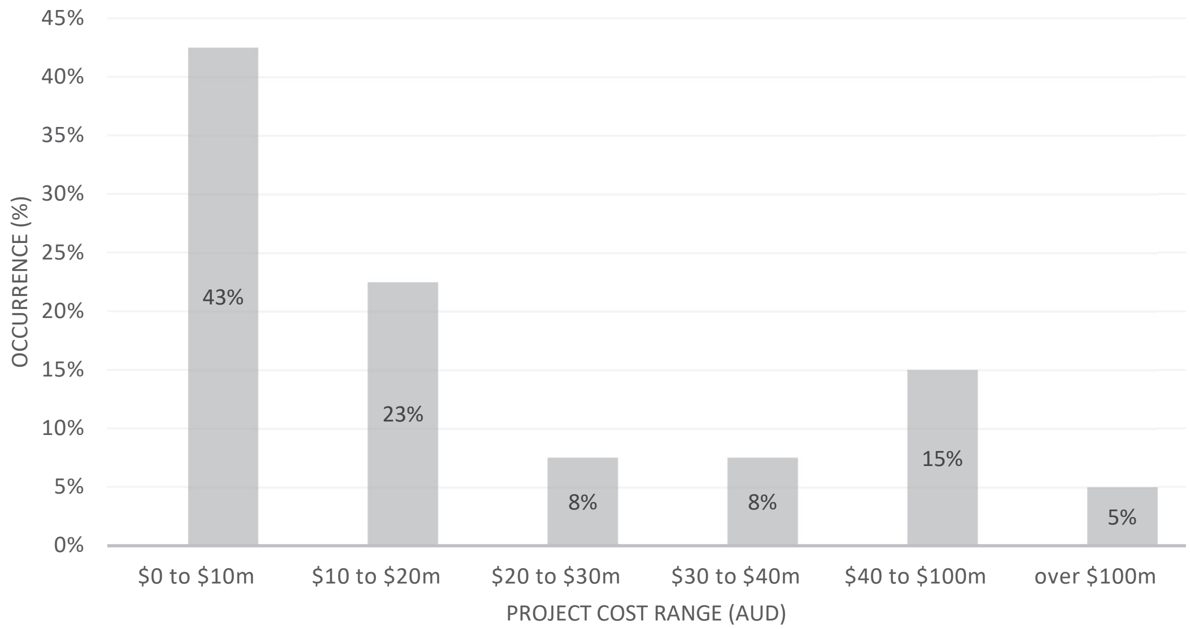


Figure 29. The Actual Cost Range of the Case Study Projects

In terms of the actual duration, 40% of the projects are finished within 12 months from the commencement date, and the actual duration of the most of the case studies is within the range of 1 to 3 years. The shortest project is finished in five months while the longest one took more than five years to complete. Figure 30 represents a graphical view of the case study projects' actual duration.

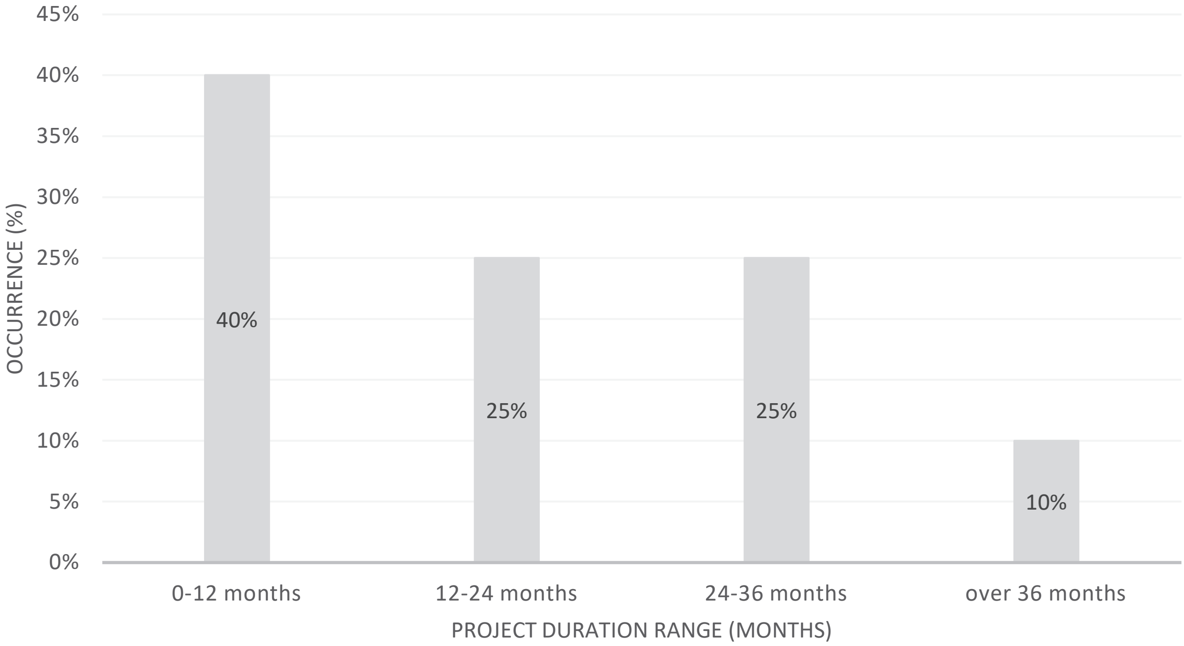


Figure 30. The Actual Time Range of the Case Study Projects

4.4 PDS AND PAR SCORES

The PDS score for each project is determined by the *i3d3* calculation engine using quantitative data obtained from case study projects. The results from examining the 40 case studies' data provided by the project managers and senior managers are presented in this section. These results include the PDS scores and PAR scores, as well as the level of complexity of each project based on the scale of the challenge, extent of uncertainty and stakeholder diversity.

As mentioned earlier, the PDS score is the percentage change between planned and actual performance, taking into account cost, time, scope and risk baselines. A positive PDS score simply means that the actual performance is better than the original plan, which implies that the expectations for delivery are exceeded. A negative PDS score indicates the project is not successful. The equation for planned and actual PDS is:

$$PDS = \frac{scope^3}{cost \times time \times risk}$$

where:

scope	=	a measure of the size or extent of the project
cost	=	the cost of implementing the project
time	=	the duration of the project from start to finish
risk	=	the √mean risk level (probability x impact) of all risk events

Six steps are involved in assessing success within this phase.

Step 1: Cost is described as the cost of the project, and both the planned cost and the actual cost are required to calculate the success score. Costs should include all cash outflows pertaining to the project, such as consulting fees, taxes, fees, approvals, commissioning and testing and rectification of deficiencies. Costs may be expressed in local or foreign currency, although, in the latter case, the same exchange rate must be used for both planned and actual expenses. Costs are not discounted to reflect the time value of the money.

Step 2: Time is the duration of the project, and it requires both the planned time and the actual time to calculate the success rate. Time may be measured in hours, days, weeks or months from start to finish without deductions for periods of non-work, holidays, weekends or delays. External disruption to production schedules must not be removed from the calculation.

Step 3: Scope is defined as the project size, and the model requires both planned scope and actual scope to calculate the success score. A suitable score measure must be assigned that represents the corresponding cost, time and/or risk variations. In order words, the unit of scope must adequately describe the extent of works in a single metric (e.g. number, length, area, volume, etc.). Scope changes during implementation must be approved.

Step 4: Risk is defined as the project's level of uncertainty, and for calculating the success score, both planned risk and actual risk are required. Risk, whether positive or negative, is the result of an event's probability (or likelihood) and the consequences (or impact) that could result if it did occur. Reduced risk is permissible when mitigation strategies are planned and included in the forecasts for scope, cost and time. A 3x3 matrix is recommended for risk calculation where probability (1-3) and consequences (1-3) are multiplied to achieve a result between 1 (minimum) and 9 (extreme) respectively. Whether they have a positive or negative influence, the overall risk level is defined as the square root of the arithmetic mean of individual risk events. The probability of all actual risks is notionally set at 3 but if they did not happen, their consequences may be lower than planned. Unforeseen risk events are only added to the actual risk calculation.

Step 5: The overall score reflects the percentage change between planned expectations and actual performance. PDS is effectively the success score, as shown in Figure 31. However, the contribution that each of the four success factors has on the PDS is determined retrospectively using an algorithm that distributes the impact that each factor has on the PDS (see hypothetical example in Table 15. Scaling of PDS Success Factors).

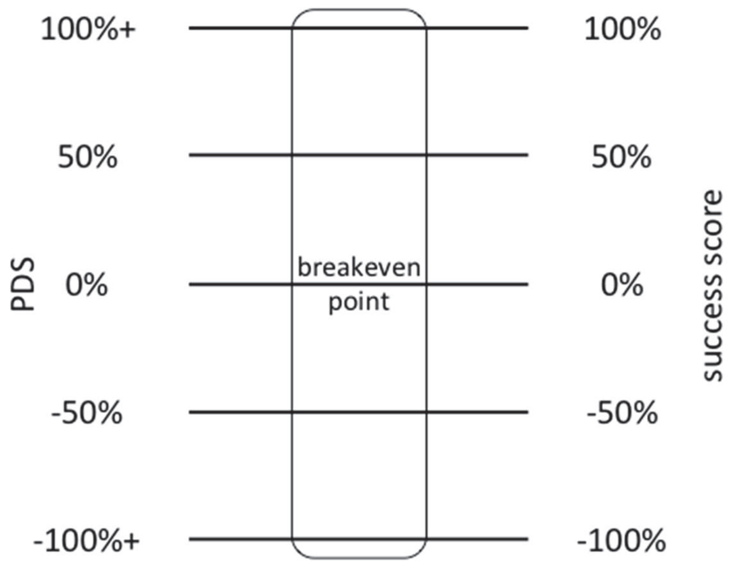


Figure 31. PDS Success Scale

Table 15. Scaling of PDS Success Factors

	Planned	Actual	Impact	%change	Scaled change
cost	25,000,000	26,500,000	117.92	-5.66%	-5.39%
time	250	240	130.21	4.17%	3.97%
scope	15,000	16,000	315.31	21.36%	20.33%
risk	2.08	2.11	255.98	-1.47%	-1.40%
				18.40%	**17.51%**
PDS	259.81	305.30		**17.51%**	-100>PDS>100

Step 6: Project complexity is concerned with the magnitude of the challenge ahead. It is not output but rather an input to the management of the change process of delivery. Complexity is considered to be a continuum from simple to chaotic. This continuum implies increased challenge from what is commonly called 'know unknowns' and 'unknown unknowns', and can even include the concept of 'wicked' problems that challenge effective resolution at all. Complexity is a variable in assessing project delivery success. In order to assess the likely position of a new project on the complexity continuum, the *Complexity Forecasting Cube* (CFC) has been utilised in this study. It takes the form of a 3D matrix that reflects simple (low score) to chaotic (high score) projects based on the three coordinates:

The complexity score is deployed to adjust for the difficulty of the project challenge, and is akin to high platform diving in that the level of difficulty of the dive chosen factors into a diver's final score. Where chaotic or high complexity potential is expected, any negative success factor is adjusted to 50% or 75% of its normal value (respectively). Where simple or low complexity potential is expected, any positive success factor is adjusted to 50% or 75% of its normal value (respectively).

The results of the PDS and PAR calculations for the 40 case study projects appear on the following pages. Due to confidentiality reasons stated in our ethics approval, the names and photographs of projects in the dataset cannot be made public.

CASE STUDY #1

PROJECT INFO	type	contract	sector
	Hospital	traditional	public

DELIVER (PDS)	-25

SUCCESS FACTOR	within budget	-40	on schedule	-75	as specified	0	no surprises	17

	planned	actual		change
Cost:				
Construction (AUD)	15,000,000	17,500,000		16.67%
Time:				
Onsite activity (calendar month)	13	20		53.85%
Scope:				
Beds	10.00	10.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.09	2.00	✔	-4.31%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-14.29%
efficiency (cost/time)		-24.17%
speed (scope/time)		-35.00%
innovation (risk/cost)		-17.98%
complication (time/risk)	✔	60.77%
impact (scope/risk)	✔	4.50%
profit ($scope^2/cost^2$)		-26.53%
people ($scope^2/time^2$)		-57.75%
planet ($scope^2/risk^2$)	✔	9.20%
progress (TBL mean)		-25.03%

COMPLEXITY

12		1-3
	X: scale	2
	Y: uncertainty	3
	Z: stakeholders	2

high

ASSESS (PAR)	70

CASE STUDY #2

PROJECT INFO	type	contract	sector
	bank office (refurbishment)	lump sum	private

DELIVER (PDS) -15

SUCCESS FACTOR	within budget	39	on schedule	0	as specified	0	no surprises	-100

Cost:	planned	actual		change
Construction (AUD)	400,000	360,000	✔	-10.00%
Time:				
Onsite activity (calendar month)	7	7	✔	0.00%
Scope:				
Area (m^2)	40.00	40.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.79	2.55		42.56%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	11.11%
efficiency (cost/time)		-10.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)	✔	58.40%
complication (time/risk)		-29.85%
impact (scope/risk)		-29.85%
profit ($scope^2/cost^2$)	✔	23.46%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)		-50.80%
progress (TBL mean)		-9.11%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR) 60

CASE STUDY #3

PROJECT INFO	type	contract	sector
	bank office (refurbishment)	lump sum	private

DELIVER (PDS)	-30

SUCCESS FACTOR	within budget	-36	on schedule	-45	as specified	0	no surprises	-38

Cost:	planned	actual		change
Construction (AUD)	450,000	500,000		11.11%
Time:				
Onsite activity (calendar month)	7	8		14.29%
Scope:				
Area (m²)	50.00	50.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.83	2.05		12.02%

-100 ≤ PDS ≤ 100

KPIs		change
value (scope/cost)		-10.00%
efficiency (cost/time)		-2.78%
speed (scope/time)		-12.50%
innovation (risk/cost)	✔	0.82%
complication (time/risk)	✔	2.02%
impact (scope/risk)		-10.73%
profit ($scope^2/cost^2$)		-19.00%
people ($scope^2/time^2$)		-23.44%
planet ($scope^2/risk^2$)		-20.31%
progress (TBL mean)		-20.92%

COMPLEXITY		1-3
2	X: scale	2
	Y: uncertainty	1
simple	Z: stakeholders	1

ASSESS (PAR)	60

CASE STUDY #4

PROJECT INFO	type	contract	sector
	bank office (renovation)	lump sum	private

DELIVER (PDS)	-25

SUCCESS FACTOR	within budget	0	on schedule	0	as specified	0	no surprises	-100

Cost:	planned	actual		change
Construction (AUD)	750,000	750,000	✔	0.00%
Time:				
Onsite activity (calendar month)	7	7	✔	0.00%
Scope:				
Area (m²)	150.00	150.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.86	2.58		38.64%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)	✔	38.64%
complication (time/risk)		-27.87%
impact (scope/risk)		-27.87%
profit (scope^2/cost^2)	✔	0.00%
people (scope^2/time^2)	✔	0.00%
planet (scope^2/risk^2)		-47.98%
progress (TBL mean)		-15.99%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR)	60

CASE STUDY #5

PROJECT INFO	type	contract	sector
	hospital (redevelopment)	lump sum	public

DELIVER (PDS) 26

SUCCESS FACTOR	within budget	-21	on schedule	100	as specified	70	no surprises	-43

Cost:	planned	actual		change
Construction (AUD)	6,300,000	6,900,000		9.52%
Time:				
Onsite activity (calendar month)	18.00	12.00	✔	-33.33%
Scope:				
Area (m²)	450.00	480.00	✔	6.67%
Risk:				
√ mean risk level (1-3)	2.11	2.56		21.09%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-2.61%
efficiency (cost/time)	✔	64.29%
speed (scope/time)	✔	60.00%
innovation (risk/cost)	✔	10.56%
complication (time/risk)		-44.94%
impact (scope/risk)		-11.91%
profit (scope²/cost²)		-5.15%
people (scope²/time²)	✔	156.00%
planet (scope²/risk²)		-22.40%
progress (TBL mean)	✔	42.82%

COMPLEXITY

12		1-3
	X: scale	2
	Y: uncertainty	3
	Z: stakeholders	2

high

ASSESS (PAR) 75

CASE STUDY #6

PROJECT INFO	type	contract	sector
	child care centre (redevelopment)	traditional	private

DELIVER (PDS) -4

SUCCESS FACTOR	within budget	-15	on schedule	-100	as specified	0	no surprises	100

Cost:	planned	actual		change
Construction (AUD)	3,330,000	3,390,000		1.80%
Time:				
Onsite activity (calendar month)	7.00	10.00		42.86%
Scope:				
Places	52.00	52.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.50	1.11	✔	-26.00%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-1.77%
efficiency (cost/time)		-28.74%
speed (scope/time)		-30.00%
innovation (risk/cost)		-27.31%
complication (time/risk)	✔	93.05%
impact (scope/risk)	✔	35.14%
profit ($scope^2/cost^2$)		-3.51%
people ($scope^2/time^2$)		-51.00%
planet ($scope^2/risk^2$)	✔	82.62%
progress (TBL mean)	✔	9.37%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR) 67

CASE STUDY #7

PROJECT INFO	type	contract	sector
	institutional building	traditional	public

DELIVER (PDS)	4

SUCCESS FACTOR	within budget	34	on schedule	-31	as specified	0	no surprises	12

Cost:	planned	actual		change
Construction (AUD)	20,000,000	18,000,000	✔	-10.00%
Time:				
Onsite activity (calendar month)	9.00	10.00		11.11%
Scope:				
Area (m²)	4,800.00	4,800.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.76	2.66	✔	-3.62%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	11.11%
efficiency (cost/time)		-19.00%
speed (scope/time)		-10.00%
innovation (risk/cost)	✔	7.09%
complication (time/risk)	✔	15.29%
impact (scope/risk)	✔	3.76%
profit ($scope^2/cost^2$)	✔	23.46%
people ($scope^2/time^2$)		-19.00%
planet ($scope^2/risk^2$)	✔	7.66%
progress (TBL mean)	✔	4.04%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	65

CASE STUDY #8

PROJECT INFO	type	contract	sector
	shopping centre	D&C	private

DELIVER (PDS)	17

SUCCESS FACTOR	within budget	-23	on schedule	-6	as specified	100	no surprises	-4

Cost:	planned	actual		change
Construction (AUD)	360,000,000	517,000,000		43.61%
Time:				
Onsite activity (calendar month)	24.00	26.00		8.33%
Scope:				
Area (m^2)	42,000.00	53,000.00	✔	26.19%
Risk:				
√ mean risk level (1-3)	1.99	2.10		5.66%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-12.13%
efficiency (cost/time)	✔	32.56%
speed (scope/time)	✔	16.48%
innovation (risk/cost)		-26.42%
complication (time/risk)	✔	2.53%
impact (scope/risk)	✔	19.43%
profit ($scope^2/cost^2$)		-22.79%
people ($scope^2/time^2$)	✔	35.68%
planet ($scope^2/risk^2$)	✔	42.63%
progress (TBL mean)	✔	18.51%

COMPLEXITY

18		1-3
chaotic	X: scale	2
	Y: uncertainty	3
	Z: stakeholders	3

ASSESS (PAR)	82

CASE STUDY #9

PROJECT INFO	type	contract	sector
	institutional building	managing contractor	public

DELIVER (PDS)	0

SUCCESS FACTOR	within budget	0	on schedule	-12	as specified	0	no surprises	14

	planned	actual		change
Cost:				
Construction (AUD)	230,000,000	230,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	60.00	66.00		10.00%
Scope:				
Area (m²)	22,500.00	22,500.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.21	2.00	✔	-9.50%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-9.09%
speed (scope/time)		-9.09%
innovation (risk/cost)		-9.50%
complication (time/risk)	✔	21.55%
impact (scope/risk)	✔	10.50%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)		-17.36%
planet ($scope^2/risk^2$)	✔	22.10%
progress (TBL mean)	✔	1.58%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	60

CASE STUDY #10

PROJECT INFO	type	contract	sector
	institutional building	ECI	public

DELIVER (PDS)	-23

SUCCESS FACTOR	within budget	0	on schedule	0	as specified	0	no surprises	-90

Cost:	planned	actual		change
Construction (AUD)	8,300,000	8,300,000	✔	0.00%
Time:				
Onsite activity (calendar month)	12.00	12.00	✔	0.00%
Scope:				
Area (m²)	2,700.00	2,700.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.73	2.24		29.10%

KPIs	-100 ≤ PDS ≤ 100	change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)	✔	29.10%
complication (time/risk)		-22.54%
impact (scope/risk)		-22.54%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)		-40.00%
progress (TBL mean)		-13.33%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	65

CASE STUDY #11

PROJECT INFO	type	contract	sector
	institutional building	traditional	public

DELIVER (PDS)	0

SUCCESS FACTOR	within budget	0	on schedule	-100	as specified	0	no surprises	100

Cost:	planned	actual		change
Construction (AUD)	82,000,000	82,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	30.00	42.00		40.00%
Scope:				
Area (m²)	10,500.00	10,500.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.24	1.73	✔	-22.54%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-28.57%
speed (scope/time)		-28.57%
innovation (risk/cost)		-22.54%
complication (time/risk)	✔	80.74%
impact (scope/risk)	✔	29.10%
profit (scope²/cost²)	✔	0.00%
people (scope²/time²)		-48.98%
planet (scope²/risk²)	✔	66.67%
progress (TBL mean)	✔	5.90%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	66

CASE STUDY #12

PROJECT INFO	type	contract	sector
	aged care facility	traditional	private

DELIVER (PDS) 16

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	-12	0	0	75

Cost:	planned	actual		change
Construction (AUD)	32,000,000	33,000,000		3.13%
Time:				
Onsite activity (calendar month)	30.00	30.00	✔	0.00%
Scope:				
Beds	153.00	153.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.24	1.73	✔	-22.54%

KPIs $-100 \leq PDS \leq 100$

KPI		change
value (scope/cost)		-3.03%
efficiency (cost/time)	✔	3.13%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-24.89%
complication (time/risk)	✔	29.10%
impact (scope/risk)	✔	29.10%
profit (scope^2/cost^2)		-5.97%
people (scope^2/time^2)	✔	0.00%
planet (scope^2/risk^2)	✔	66.67%
progress (TBL mean)	✔	20.23%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR) 70

CASE STUDY #13

PROJECT INFO	type	contract	sector
	head office	D&C	private

DELIVER (PDS) 31

SUCCESS FACTOR	within budget	28	on schedule	0	as specified	0	no surprises	97

Cost:	planned	actual		change
Construction (AUD)	5,285,590	4,952,212	✔	-6.31%
Time:				
Onsite activity (calendar month)	7.00	7.00	✔	0.00%
Scope:				
Area (m²)	1,760.00	1,760.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.57	2.09	✔	-18.74%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	6.73%
efficiency (cost/time)		-6.31%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-13.27%
complication (time/risk)	✔	23.06%
impact (scope/risk)	✔	23.06%
profit (scope²/cost²)	✔	13.92%
people (scope²/time²)	✔	0.00%
planet (scope²/risk²)	✔	51.43%
progress (TBL mean)	✔	21.78%

COMPLEXITY		1-3
18	X: scale	2
	Y: uncertainty	3
chaotic	Z: stakeholders	3

ASSESS (PAR) 78

CASE STUDY #14

PROJECT INFO	type	contract	sector
	institutional building	lump sum	private

DELIVER (PDS)	-30

SUCCESS FACTOR	within budget	-97	on schedule	-100	as specified	75	no surprises	0

Cost:	planned	actual		change
Construction (AUD)	37,000,000	43,000,000		16.22%
Time:				
Onsite activity (calendar month)	15.00	22.00		46.67%
Scope:				
Area (m²)	9,500.00	10,450.00	✔	10.00%
Risk:				
√ mean risk level (1-3)	2.24	2.24	✔	0.00%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)		-5.35%
efficiency (cost/time)		-20.76%
speed (scope/time)		-25.00%
innovation (risk/cost)		-13.95%
complication (time/risk)	✔	46.67%
impact (scope/risk)	✔	10.00%
profit ($scope^2/cost^2$)		-10.41%
people ($scope^2/time^2$)		-43.75%
planet ($scope^2/risk^2$)	✔	21.00%
progress (TBL mean)		-11.05%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR)	59

CASE STUDY #15				
PROJECT INFO	type: commercial building	contract: D&C	sector: private	
DELIVER (PDS)	8			
SUCCESS FACTOR	within budget 0	on schedule 0	as specified 0	no surprises 32

	planned	actual		change
Cost:				
Construction (AUD)	55,000,000	55,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	48.00	48.00	✔	0.00%
Scope:				
Area (m²)	75,000.00	75,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.65	2.45	✔	-7.42%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-7.42%
complication (time/risk)	✔	8.01%
impact (scope/risk)	✔	8.01%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)	✔	16.67%
progress (TBL mean)	✔	5.56%

COMPLEXITY		1-3
8 complex	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	2

ASSESS (PAR)	67

CASE STUDY #16

PROJECT INFO	type	contract	sector
	residential building	D&C	private

DELIVER (PDS)	-11

SUCCESS FACTOR	within budget	0	on schedule	0	as specified	0	no surprises	-42

	planned	actual		change
Cost:				
Construction (AUD)	16,000,000	16,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	24.00	24.00	✔	0.00%
Scope:				
Area (m²)	7,700.00	7,700.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.00	2.24		11.80%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)	✔	11.80%
complication (time/risk)		-10.56%
impact (scope/risk)		-10.56%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)		-20.00%
progress (TBL mean)		-6.67%

COMPLEXITY

4 (low)		1-3
	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	1

ASSESS (PAR)	63

CASE STUDY #17

PROJECT INFO	type	contract	sector
	office (fit out)	lump sum	public

DELIVER (PDS)	25

SUCCESS FACTOR	within budget	0	on schedule	0	as specified	0	no surprises	100

	planned	actual		change
Cost:				
Construction (AUD)	5,000,000	5,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	10.00	10.00	✔	0.00%
Scope:				
Area (m^2)	1,100.00	1,100.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.45	1.73	✔	-29.29%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-29.29%
complication (time/risk)	✔	41.42%
impact (scope/risk)	✔	41.42%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)	✔	100.00%
progress (TBL mean)	✔	33.33%

COMPLEXITY		1-3
12	X: scale	2
	Y: uncertainty	3
high	Z: stakeholders	2

ASSESS (PAR)	81

CASE STUDY #18

PROJECT INFO	type	contract	sector
	bank office	lump sum	private

DELIVER (PDS) 0

SUCCESS FACTOR within budget 15 | on schedule -32 | as specified 0 | no surprises 17

	planned	actual		change
Cost:				
Construction (AUD)	75,000,000	70,000,000	✔	-6.67%
Time:				
Onsite activity (calendar month)	24.00	27.00		12.50%
Scope:				
Area (m²)	40,000.00	40,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.65	2.45	✔	-7.42%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	7.14%
efficiency (cost/time)		-17.04%
speed (scope/time)		-11.11%
innovation (risk/cost)		-0.80%
complication (time/risk)	✔	21.51%
impact (scope/risk)	✔	8.01%
profit ($scope^2/cost^2$)	✔	14.80%
people ($scope^2/time^2$)		-20.99%
planet ($scope^2/risk^2$)	✔	16.67%
progress (TBL mean)	✔	3.49%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR) 65

CASE STUDY #19

PROJECT INFO	type	contract	sector
	facility in airport	traditional	private

DELIVER (PDS) -43

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	0	-100	0	-73

Cost:	planned	actual		change
Construction (AUD)	500,000	500,000	✔	0.00%
Time:				
Onsite activity (calendar week)	6.00	9.00		50.00%
Scope:				
Area (m²)	500.00	500.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.24	2.83		26.49%

KPIs -100 ≤ PDS ≤ 100

KPI		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-33.33%
speed (scope/time)		-33.33%
innovation (risk/cost)	✔	26.49%
complication (time/risk)	✔	18.59%
impact (scope/risk)		-20.94%
profit (scope²/cost²)	✔	0.00%
people (scope²/time²)		-55.56%
planet (scope²/risk²)		-37.50%
progress (TBL mean)		-31.02%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	1
low	Z: stakeholders	2

ASSESS (PAR) 62

CASE STUDY #20

PROJECT INFO	type	contract	sector
	health facility (redevelopment)	traditional	public

DELIVER (PDS) 10

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	0	0	0	40

	planned	actual		change
Cost:				
Construction (AUD)	2,000,000	2,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	5.00	5.00	✔	0.00%
Scope:				
Area (m²)	5,000.00	5,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.20	2.00	✔	-9.09%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-9.09%
complication (time/risk)	✔	10.00%
impact (scope/risk)	✔	10.00%
profit (scope²/cost²)	✔	0.00%
people (scope²/time²)	✔	0.00%
planet (scope²/risk²)	✔	21.00%
progress (TBL mean)	✔	7.00%

COMPLEXITY

8 complex		1-3
	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	2

ASSESS (PAR) 71

CASE STUDY #21

PROJECT INFO	type	contract	sector
	airport (safety enhancement)	D&C	public

DELIVER (PDS) 0

SUCCESS FACTOR	within budget	-100	on schedule	0	as specified	0	no surprises	100

	planned	actual		change
Cost:				
Construction (AUD)	2,000,000	2,600,000		30.00%
Time:				
Onsite activity (calendar month)	5.00	5.00	✔	0.00%
Scope:				
number of	3.00	3.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.65	2.24	✔	-15.48%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-23.08%
efficiency (cost/time)	✔	30.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-34.99%
complication (time/risk)	✔	18.32%
impact (scope/risk)	✔	18.32%
profit ($scope^2/cost^2$)		-40.83%
people ($scope^2/time^2$)	✔	0.00%
planet ($scope^2/risk^2$)	✔	40.00%
progress (TBL mean)		-0.28%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR) 69

CASE STUDY #22

PROJECT INFO	type	contract	sector
	office (refurbishment)	cost plus	private

DELIVER (PDS) 9

SUCCESS FACTOR	within budget	0	on schedule	0	as specified	0	no surprises	36

	planned	actual		change
Cost:				
Construction (AUD)	4,000,000	4,000,000	✔	0.00%
Time:				
Onsite activity (calendar month)	11.00	11.00	✔	0.00%
Scope:				
Area (m²)	4,000.00	4,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.95	1.79	✔	-8.23%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)		-8.23%
complication (time/risk)	✔	8.97%
impact (scope/risk)	✔	8.97%
profit (scope^2/cost^2)	✔	0.00%
people (scope^2/time^2)	✔	0.00%
planet (scope^2/risk^2)	✔	18.75%
progress (TBL mean)	✔	6.25%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR) 64

CASE STUDY #23

PROJECT INFO	type	contract	sector
	airport facility (expansion)	construct only	public

DELIVER (PDS) 17

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	49	-12	0	32

	planned	actual		change
Cost:				
Construction (AUD)	45,000,000	40,000,000	✔	-11.11%
Time:				
Onsite activity (calendar month)	23.00	24.50		6.52%
Scope:				
Area (m²)	50,000.00	50,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.42	2.24	✔	-7.55%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	12.50%
efficiency (cost/time)		-16.55%
speed (scope/time)		-6.12%
innovation (risk/cost)	✔	4.01%
complication (time/risk)	✔	15.22%
impact (scope/risk)	✔	8.17%
profit ($scope^2/cost^2$)	✔	26.56%
people ($scope^2/time^2$)		-11.87%
planet ($scope^2/risk^2$)	✔	17.00%
progress (TBL mean)	✔	10.56%

COMPLEXITY

18		1-3
	X: scale	2
	Y: uncertainty	3
	Z: stakeholders	3

chaotic

ASSESS (PAR) 79

CASE STUDY #24

PROJECT INFO	type	contract	sector
	airline lounge (renovation)	D&C	private

DELIVER (PDS) -34

SUCCESS FACTOR	within budget	-11	on schedule	-83	as specified	0	no surprises	-43

Cost:	planned	actual		change
Construction (AUD)	40,800,000	42,100,000		3.19%
Time:				
Onsite activity (calendar month)	20.00	26.00		30.00%
Scope:				
Area (m²)	1,600.00	1,600.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.65	3.00		13.39%

KPIs $-100 \le PDS \le 100$

		change
value (scope/cost)		-3.09%
efficiency (cost/time)		-20.63%
speed (scope/time)		-23.08%
innovation (risk/cost)	✔	9.89%
complication (time/risk)	✔	14.65%
impact (scope/risk)		-11.81%
profit ($scope^2/cost^2$)		-6.08%
people ($scope^2/time^2$)		-40.83%
planet ($scope^2/risk^2$)		-22.22%
progress (TBL mean)		-23.04%

COMPLEXITY

8 complex		1-3
	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	2

ASSESS (PAR) 57

CASE STUDY #25

PROJECT INFO	type	contract	sector
	institutional building	traditional	public

DELIVER (PDS)	11

SUCCESS FACTOR	within budget	-3	on schedule	100	as specified	0	no surprises	-53

Cost:	planned	actual		change
Construction (AUD)	11,534,486	11,686,062		1.31%
Time:				
Onsite activity (calendar month)	20.00	13.00	✔	-35.00%
Scope:				
Area (m²)	5,360.00	5,360.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.95	2.54		30.26%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)		-1.30%
efficiency (cost/time)	✔	55.87%
speed (scope/time)	✔	53.85%
innovation (risk/cost)	✔	28.57%
complication (time/risk)		-50.10%
impact (scope/risk)		-23.23%
profit ($scope^2/cost^2$)		-2.58%
people ($scope^2/time^2$)	✔	136.69%
planet ($scope^2/risk^2$)		-41.06%
progress (TBL mean)	✔	31.02%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	85

CASE STUDY #26

PROJECT INFO	type	contract	sector
	library (refurbishment)	D&C	private

DELIVER (PDS) -27

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	31	-51	0	-87

	planned	actual		change
Cost:				
Construction (AUD)	43,400,000	39,435,000	✔	-9.14%
Time:				
Onsite activity (calendar month)	21.00	24.00		14.29%
Scope:				
Seatings	750.00	750.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.00	2.54		27.00%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	10.05%
efficiency (cost/time)		-20.49%
speed (scope/time)		-12.50%
innovation (risk/cost)	✔	39.77%
complication (time/risk)		-10.01%
impact (scope/risk)		-21.26%
profit ($scope^2/cost^2$)	✔	21.12%
people ($scope^2/time^2$)		-23.44%
planet ($scope^2/risk^2$)		-38.00%
progress (TBL mean)		-13.44%

COMPLEXITY

4 (low)		1-3
	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	1

ASSESS (PAR) 64

CASE STUDY #27

PROJECT INFO	type	contract	sector
	landscaping	traditional	private

DELIVER (PDS) -56

SUCCESS FACTOR	within budget	-79	on schedule	-100	as specified	0	no surprises	-45

Cost:	planned	actual		change
Construction (AUD)	6,250,000	8,387,021		34.19%
Time:				
Onsite activity (calendar month)	16.00	26.00		62.50%
Scope:				
Area (m²)	1,200.00	1,200.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.41	1.65		16.83%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)		-25.48%
efficiency (cost/time)		-17.42%
speed (scope/time)		-38.46%
innovation (risk/cost)		-12.94%
complication (time/risk)	✔	39.09%
impact (scope/risk)		-14.41%
profit ($scope^2/cost^2$)		-44.47%
people ($scope^2/time^2$)		-62.13%
planet ($scope^2/risk^2$)		-26.74%
progress (TBL mean)		-44.45%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR) 69

CASE STUDY #28

PROJECT INFO	type	contract	sector
	hospital (extension)	lump sum	private

DELIVER (PDS) -27

SUCCESS FACTOR	within budget	-20	on schedule	-39	as specified	0	no surprises	-50

Cost:	planned	actual		change
Construction (AUD)	52,000,000	60,000,000		15.38%
Time:				
Onsite activity (calendar month)	26.00	35.00		34.62%
Scope:				
Beds	46.00	46.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.58	2.92		84.39%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)		-13.33%
efficiency (cost/time)		-14.29%
speed (scope/time)		-25.71%
innovation (risk/cost)	✔	59.81%
complication (time/risk)		-26.99%
impact (scope/risk)		-45.77%
profit (scope^2/cost^2)		-24.89%
people (scope^2/time^2)		-44.82%
planet (scope^2/risk^2)		-70.59%
progress (TBL mean)		-46.76%

COMPLEXITY		1-3
18	X: scale	2
	Y: uncertainty	3
chaotic	Z: stakeholders	3

ASSESS (PAR) 68

CASE STUDY #29

PROJECT INFO	type	contract	sector
	university lab	managing contractor	private

DELIVER (PDS)	-1

SUCCESS FACTOR	within budget	-61	on schedule	76	as specified	0	no surprises	-21

Cost:	planned	actual		change
Construction (AUD)	13,000,000	15,329,280		17.92%
Time:				
Onsite activity (calendar month)	16.00	14.00	✔	-12.50%
Scope:				
Area (m²)	2,700.00	2,700.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.12	2.24		5.41%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)		-15.19%
efficiency (cost/time)	✔	34.76%
speed (scope/time)	✔	14.29%
innovation (risk/cost)		-10.61%
complication (time/risk)		-16.99%
impact (scope/risk)		-5.13%
profit (scope²/cost²)		-28.08%
people (scope²/time²)	✔	30.61%
planet (scope²/risk²)		-10.00%
progress (TBL mean)		-2.49%

COMPLEXITY		1-3
12	X: scale	2
high	Y: uncertainty	2
	Z: stakeholders	3

ASSESS (PAR)	72

CASE STUDY #30

PROJECT INFO	type	contract	sector
	library (redevelopment)	traditional	public

DELIVER (PDS) -41

SUCCESS FACTOR	within budget	-23	on schedule	-67	as specified	0	no surprises	-75

Cost:	planned	actual		change
Construction (AUD)	26,600,000	29,465,691		10.77%
Time:				
Onsite activity (calendar month)	15.00	21.00		40.00%
Scope:				
Seatings	300.00	300.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.58	2.74		73.21%

KPIs $-100 \le PDS \le 100$

		change
value (scope/cost)		-9.73%
efficiency (cost/time)		-20.88%
speed (scope/time)		-28.57%
innovation (risk/cost)	✔	56.36%
complication (time/risk)		-19.17%
impact (scope/risk)		-42.26%
profit (scope^2/cost^2)		-18.51%
people (scope^2/time^2)		-48.98%
planet (scope^2/risk^2)		-66.67%
progress (TBL mean)		-44.72%

COMPLEXITY		1-3
12	X: scale	2
	Y: uncertainty	3
high	Z: stakeholders	2

ASSESS (PAR) 63

CASE STUDY #31

PROJECT INFO	type	contract	sector
	library (redevelopment)	traditional	public

DELIVER (PDS)	-52

SUCCESS FACTOR	within budget	-91	on schedule	-72	as specified	0	no surprises	-46

	planned	actual		change
Cost:				
Construction (AUD)	14,315,804	19,973,683		39.52%
Time:				
Onsite activity (calendar month)	14.00	18.00		28.57%
Scope:				
Area (m2)	2,040.00	2,040.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.92	2.24		16.72%

KPIs $-100 \le PDS \le 100$

		change
value (scope/cost)		-28.33%
efficiency (cost/time)	✔	8.52%
speed (scope/time)		-22.22%
innovation (risk/cost)		-16.34%
complication (time/risk)	✔	10.15%
impact (scope/risk)		-14.33%
profit ($scope^2/cost^2$)		-48.63%
people ($scope^2/time^2$)		-39.51%
planet ($scope^2/risk^2$)		-26.60%
progress (TBL mean)		-38.25%

COMPLEXITY		1-3
8	X: scale	2
complex	Y: uncertainty	2
	Z: stakeholders	2

ASSESS (PAR)	68

CASE STUDY #32

PROJECT INFO	type	contract	sector
	landscaping	traditional	private

DELIVER (PDS)	-48

SUCCESS FACTOR	within budget	-21	on schedule	-100	as specified	0	no surprises	-72

	planned	actual		change
Cost:				
Construction (AUD)	9,971,351	10,642,150		6.73%
Time:				
Onsite activity (calendar month)	21.00	32.00		52.38%
Scope:				
Area (m2)	2,200.00	2,200.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.00	2.55		27.48%

KPIs $-100 \le PDS \le 100$

		change
value (scope/cost)		-6.30%
efficiency (cost/time)		-29.96%
speed (scope/time)		-34.38%
innovation (risk/cost)	✔	19.44%
complication (time/risk)	✔	19.54%
impact (scope/risk)		-21.55%
profit ($scope^2/cost^2$)		-12.21%
people ($scope^2/time^2$)		-56.93%
planet ($scope^2/risk^2$)		-38.46%
progress (TBL mean)		-35.87%

COMPLEXITY

8		1-3
	X: scale	2
	Y: uncertainty	2
	Z: stakeholders	2

complex

ASSESS (PAR)	74

CASE STUDY #33

PROJECT INFO	type	contract	sector
	institutional buildings	traditional	private

DELIVER (PDS)	-12

SUCCESS FACTOR	within budget	-6	on schedule	-5	as specified	0	no surprises	-38

Cost:	planned	actual		change
Construction (AUD)	20,560,000	21,267,673		3.44%
Time:				
Onsite activity (calendar month)	35.00	36.00		2.86%
Scope:				
Area (m2)	9,600.00	9,600.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.96	2.45		25.16%

KPIs $-100 \le PDS \le 100$

		change
value (scope/cost)		-3.33%
efficiency (cost/time)	✔	0.57%
speed (scope/time)		-2.78%
innovation (risk/cost)	✔	21.00%
complication (time/risk)		-17.82%
impact (scope/risk)		-20.10%
profit (scope^2/cost^2)		-6.54%
people (scope^2/time^2)		-5.48%
planet (scope^2/risk^2)		-36.17%
progress (TBL mean)		-16.06%

COMPLEXITY		1-3
18	X: scale	2
chaotic	Y: uncertainty	3
	Z: stakeholders	3

ASSESS (PAR)	73

CASE STUDY #34

PROJECT INFO	type	contract	sector
	institutional building	traditional	public

DELIVER (PDS) -53

SUCCESS FACTOR	within budget	-81	on schedule	-50	as specified	0	no surprises	-80

Cost:	planned	actual		change
Construction (AUD)	7,000,000	9,375,435		33.93%
Time:				
Onsite activity (calendar month)	16.00	19.00		18.75%
Scope:				
Area (m2)	8,000.00	8,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.92	2.55		33.08%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)		-25.34%
efficiency (cost/time)	✔	12.79%
speed (scope/time)		-15.79%
innovation (risk/cost)		-0.64%
complication (time/risk)		-10.77%
impact (scope/risk)		-24.86%
profit (scope^2/cost^2)		-44.25%
people (scope^2/time^2)		-29.09%
planet (scope^2/risk^2)		-43.54%
progress (TBL mean)		-38.96%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR) 79

CASE STUDY #35

PROJECT INFO	type	contract	sector
	entertainment (redevelopment)	D&C	private

DELIVER (PDS) -18

SUCCESS FACTOR	within budget	on schedule	as specified	no surprises
	0	0	0	-71

Cost:	planned	actual		change
Construction (AUD)	6,600,000	6,600,000	✔	0.00%
Time:				
Onsite activity (calendar month)	30.00	30.00	✔	0.00%
Scope:				
Area (m2)	864.00	864.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.87	2.45		30.96%

KPIs $-100 \leq PDS \leq 100$

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)	✔	0.00%
speed (scope/time)	✔	0.00%
innovation (risk/cost)	✔	30.96%
complication (time/risk)		-23.64%
impact (scope/risk)		-23.64%
profit (scope^2/cost^2)	✔	0.00%
people (scope^2/time^2)	✔	0.00%
planet (scope^2/risk^2)		-41.70%
progress (TBL mean)		-13.90%

COMPLEXITY		1-3
12	X: scale	2
	Y: uncertainty	3
high	Z: stakeholders	2

ASSESS (PAR) 68

CASE STUDY #36

PROJECT INFO	type	contract	sector
	residential buildings	D&C	private

DELIVER (PDS)	-19

SUCCESS FACTOR	within budget	0	on schedule	-75	as specified	0	no surprises	0

Cost:	planned	actual		change
Construction (AUD)	17,500,000	17,500,000	✔	0.00%
Time:				
Onsite activity (calendar month)	15.00	22.00		46.67%
Scope:				
Area (m2)	5,760.00	5,760.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.64	2.64	✔	0.00%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-31.82%
speed (scope/time)		-31.82%
innovation (risk/cost)	✔	0.00%
complication (time/risk)	✔	46.67%
impact (scope/risk)	✔	0.00%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)		-53.51%
planet ($scope^2/risk^2$)	✔	0.00%
progress (TBL mean)		-17.84%

COMPLEXITY		1-3
12	X: scale	2
	Y: uncertainty	3
high	Z: stakeholders	2

ASSESS (PAR)	68

CASE STUDY #37

PROJECT INFO	type	contract	sector
	institutional building (renovation)	lump sum	private

DELIVER (PDS)	-1

SUCCESS FACTOR	within budget	-5	on schedule	-17	as specified	0	no surprises	20

Cost:	planned	actual		change
Construction (AUD)	2,480,987	2,618,889		5.56%
Time:				
Onsite activity (calendar month)	5.00	6.00		20.00%
Scope:				
Places	4.00	4.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.51	2.00	✔	-20.32%

-100 ≤ PDS ≤ 100

KPIs		change
value (scope/cost)		-5.27%
efficiency (cost/time)		-12.03%
speed (scope/time)		-16.67%
innovation (risk/cost)		-24.51%
complication (time/risk)	✔	50.60%
impact (scope/risk)	✔	25.50%
profit ($scope^2/cost^2$)		-10.25%
people ($scope^2/time^2$)		-30.56%
planet ($scope^2/risk^2$)	✔	57.50%
progress (TBL mean)	✔	5.56%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR)	78

CASE STUDY #38

PROJECT INFO	type	contract	sector
	institutional buildning	traditional	public

DELIVER (PDS)	-29

SUCCESS FACTOR	within budget	-37	on schedule	-75	as specified	0	no surprises	-5

Cost:	planned	actual		change
Construction (AUD)	17,000,000	19,800,000		16.47%
Time:				
Onsite activity (calendar month)	7.00	12.00		71.43%
Scope:				
Area (m²)	1,500.00	1,500.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	2.08	2.12		1.92%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)		-14.14%
efficiency (cost/time)		-32.06%
speed (scope/time)		-41.67%
innovation (risk/cost)		-12.49%
complication (time/risk)	✔	68.19%
impact (scope/risk)		-1.89%
profit (scope²/cost²)		-26.28%
people (scope²/time²)		-65.97%
planet (scope²/risk²)		-3.74%
progress (TBL mean)		-32.00%

COMPLEXITY		1-3
12	X: scale	2
	Y: uncertainty	3
high	Z: stakeholders	2

ASSESS (PAR)	67

CASE STUDY #39

PROJECT INFO	type	contract	sector
	aged care (renovation)	traditional	private

DELIVER (PDS)	-41

SUCCESS FACTOR	within budget	0	on schedule	-78	as specified	0	no surprises	-87

Cost:	planned	actual		change
Construction (AUD)	22,100,000	22,100,000	✔	0.00%
Time:				
Onsite activity (calendar month)	39.00	50.00		28.21%
Scope:				
Beds	25.00	25.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.68	2.23		32.74%

KPIs		-100 ≤ PDS ≤ 100 change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-22.00%
speed (scope/time)		-22.00%
innovation (risk/cost)	✔	32.74%
complication (time/risk)		-3.41%
impact (scope/risk)		-24.66%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)		-39.16%
planet ($scope^2/risk^2$)		-43.24%
progress (TBL mean)		-27.47%

COMPLEXITY		1-3
8	X: scale	2
	Y: uncertainty	2
complex	Z: stakeholders	2

ASSESS (PAR)	60

CASE STUDY #40

PROJECT INFO	type	contract	sector
	park (redevelopment)	D&C	public

DELIVER (PDS) -33

SUCCESS FACTOR	within budget	0	on schedule	-31	as specified	0	no surprises	-100

	planned	actual		change
Cost:				
Construction (AUD)	2,830,652	2,830,652	✔	0.00%
Time:				
Onsite activity (calendar month)	11.00	12.00		9.09%
Scope:				
visitor	2,000.00	2,000.00	✔	0.00%
Risk:				
√ mean risk level (1-3)	1.73	2.54		46.82%

KPIs -100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	0.00%
efficiency (cost/time)		-8.33%
speed (scope/time)		-8.33%
innovation (risk/cost)	✔	46.82%
complication (time/risk)		-25.70%
impact (scope/risk)		-31.89%
profit ($scope^2/cost^2$)	✔	0.00%
people ($scope^2/time^2$)		-15.97%
planet ($scope^2/risk^2$)		-53.61%
progress (TBL mean)		-23.19%

COMPLEXITY		1-3
4	X: scale	2
	Y: uncertainty	2
low	Z: stakeholders	1

ASSESS (PAR) 58

4.5 CORRELATION (PDS VS. PAR) AND RELIABILITY TESTING

Some of the case studies are removed from the analysis due to external factors that significantly affected their performance, leading to unreliable PDS ratings. This does not mean that the model cannot assess the performance of these projects, but rather they significantly distort the correlation and are therefore treated as outliers. These projects and the reasons for their elimination can be seen in Table 16.

Table 16. Eliminated Case Studies and the Reasons for Elimination

Case Study No.	Reason for elimination
1	The client had put a hold on the project due to the interference that the construction process had with the existing medical procedures and also to prevent health issues for the patients.
25	Unreliable and inadequate project information that was discovered during the analysis.
27	Significant time and cost overruns due to insufficient funds, ingrained conditions. Also, access to the site, which should have been provided by the client had faced several issues and caused considerable delays.
31	Latent conditions and a safety incident had impacted the project drastically.
32	Adjacent projects had been running simultaneously with this project that caused significant delays to the project's activities.
34	A significant change to the project's cost happened due to the latent conditions that had been overlooked by the client.

For the purpose of this study and to satisfy the triangulation method requirements, the PDS scores are correlated against the PAR scores to assess whether or not project managers from the more successful projects have also performed well in incorporating the project management processes in the eyes of senior managers. However, this methodology is not intended to predict a cause and effect relationship between the PDS and PAR scores, and this is done solely to test the scores calculated by the 3D integration model. Triangulation is needed in this study, as there are multiple approaches to data collection within the case study (Bryman, 2011). The 3D integration model calculates the PDS score for the remaining case studies based on the planned and actual values of scope, cost, time and risk, and also the complexity factor. On the other hand, PAR scores are captured using a PMBOK-based questionnaire asking senior managers how well the project managers implemented the processes of project management. These scores are shown in Table 17.

Table 17. PAR and PDS Scores (sorted by PDS)

Case Study Number	PDS	PAR
CS#13	31%	78%
CS#5	26%	75%
CS#17	25%	81%
CS#8	17%	82%
CS#23	17%	79%
CS#12	16%	70%
CS#20	10%	71%
CS#22	9%	64%
CS#15	8%	67%
CS#7	4%	65%
CS#9	0%	60%
CS#11	0%	66%
CS#18	0%	65%
CS#21	0%	69%
CS#29	-1%	72%
CS#37	-1%	78%
CS#6	-4%	67%
CS#16	-11%	63%
CS#33	-12%	73%
CS#2	-15%	60%
CS#35	-18%	68%
CS#36	-19%	68%
CS#10	-23%	65%
CS#4	-25%	60%
CS#26	-27%	64%
CS#28	-27%	68%
CS#38	-29%	67%
CS#3	-30%	60%
CS#14	-30%	59%
CS#40	-33%	58%
CS#24	-34%	57%
CS#30	-41%	63%
CS#39	-41%	60%
CS#19	-43%	62%

Simple linear regression is used to find the relationship between PAR and PDS scores, with PAR as the regressor. The analysis shows that the relationship could be perfectly fitted with simple linear regression, as the scatter diagram shows (Figure 32, Figure 33 and Figure 34).

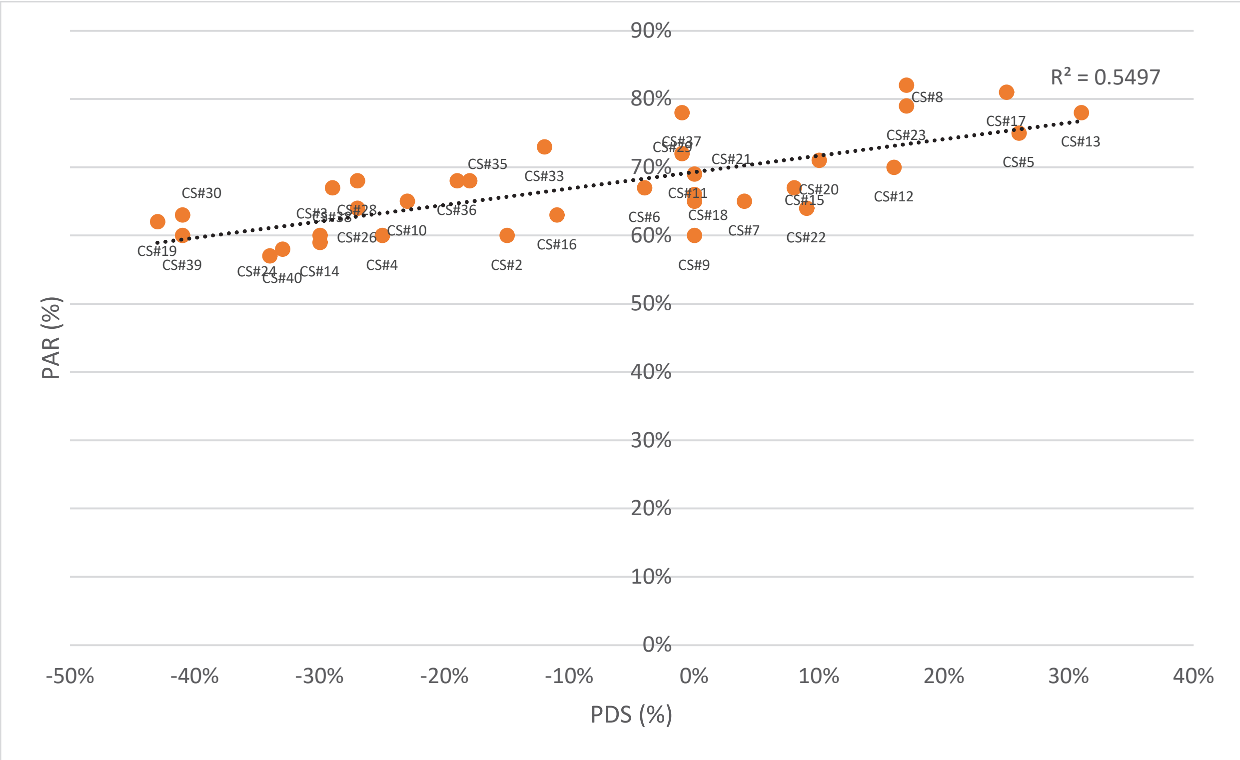


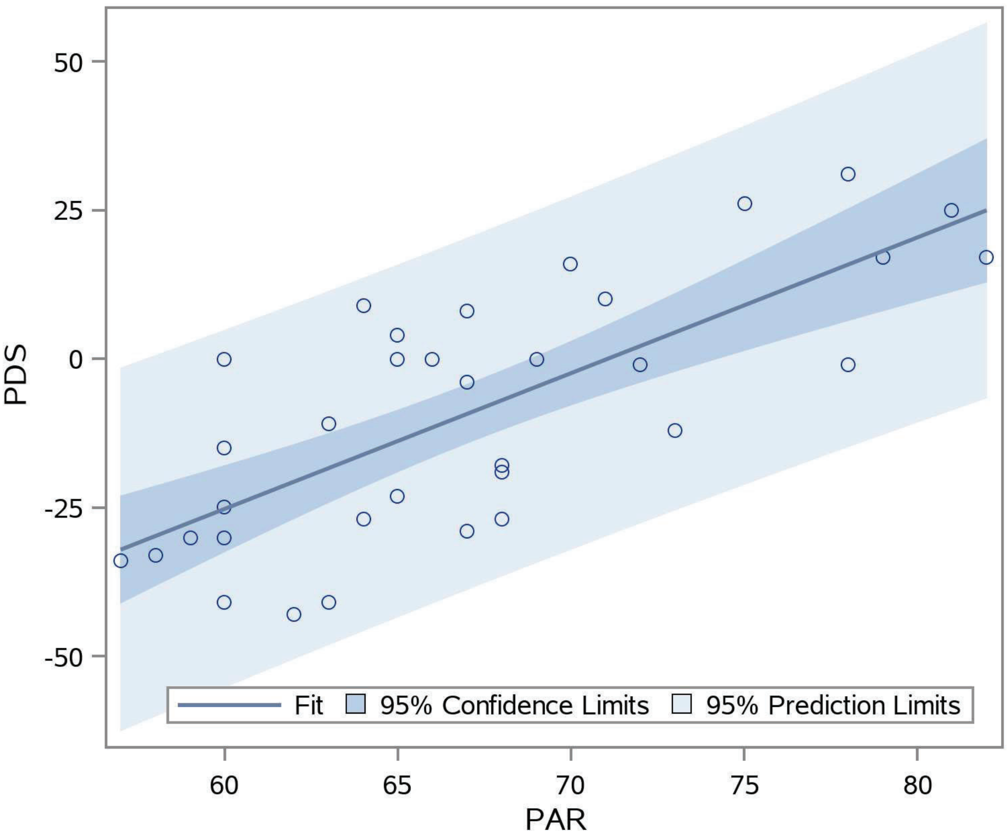
Figure 32. PDS and PAR Relationship

According to Table 18, both intercept and the coefficient are statistically significant, and PDS could be predicted using PAR with a precision of 53.6% (adjusted R-square). The diagnostics diagram also shows that the model has no flaws, as the distribution of residuals is normal and homoscedastic (Figure 34).

Table 18. Regression Parameters of The Linear Relationship Between PAR and PDS

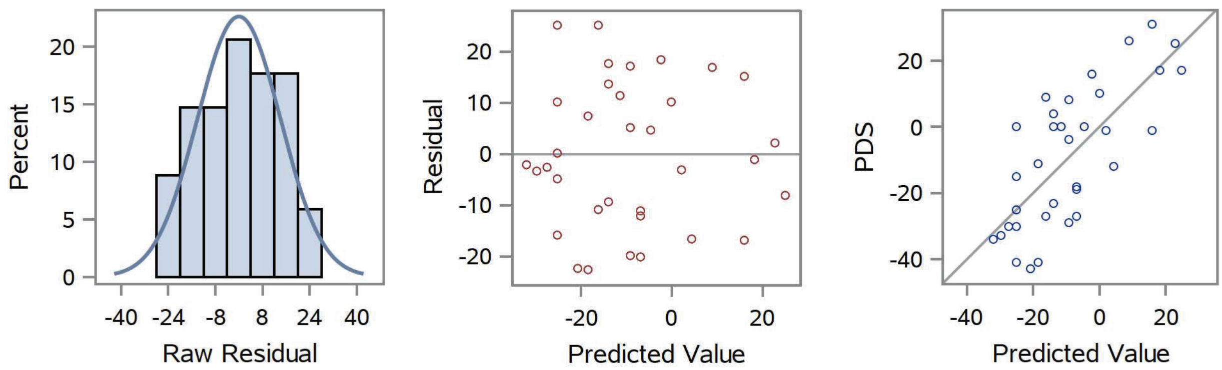
Parameter	Estimate	Standard error	T value	PR> |T|
B_0	-162.14	24.65	-6.58	<.0001
B_1	2.282	0.365	6.25	<.0001
	Root MSE	R-Square	Adjusted R-Square	
	14.33	0.55	0.536	

Note. PAR as the Regressor



Note. With Model Parameters of 95% Confidence Limits (Dark Blue) and Model Prediction Limits (Light Blue)-Method: Gauss-Newton

Figure 33. Regression Diagram of the PDS-PAR Relationship



Note. (Left To Right: Raw Residual Distribution Against Normal Distribution, Residuals Scatter Plot Against PDS Predicted Value, and Actual Vs Predicted Values of PDS).

Figure 34. Regression Diagnostics Diagram

A bootstrap method is employed for the reliability test. The results of bootstrapping show that the estimated parameters are both well fitted in the bootstrap bias-corrected 95% confidence limits. The difference between raw and bootstrapped confidence limits is the result of having a large sample size in the bootstrap method; however, this difference is negligible for both model parameters. The parameter's standard error and bootstrap standard deviation are also very close, which is another proof of model reliability (see Table 19).

Table 19. Model Parameter Estimates Based on Raw and Bootstrapped Sample

Parameter	Estimate	Standard Error	Approximate 95% Confidence Limits		Bootstrap Standard Deviation	Bootstrap Bias-Corrected 95% Confidence Limits	
B_0	-162.14	24.65	-212.3	-111.9	24.81	-210.7	-114
B_1	2.282	0.365	1.538	3.025	0.368	1.57	2.99

4.6 CONCLUDING REMARKS

In this chapter, the data from the 40 case study projects obtained through several interviews are analysed in order to validate the PDS scores. First, descriptive details were provided to provide insights into the context of the case study projects and to assess the size and nature of the projects examined in the research. Next, the scope, time, cost, risk, PDS, PAR and KPI values for each project are reported separately, followed by the explanations for excluding six projects from the analysis. The association between PDS and PAR scores is then measured using Pearson's correlation coefficient test, which shows a strong relationship between the two sets of data fulfilling the requirements of the triangulation approach. The reliability of the work was also tested via the bootstrap technique. The findings of the study are interpreted and discussed in the following chapter to illustrate the functionality of the 3D integration model.

CHAPTER 5: DISCUSSION

5.1 THE PURPOSE OF THIS CHAPTER

Chapter 4 presented the results from the model and the performance assessment review and discussed the correlation between the two key variables of PDS and PAR. This chapter provides the researcher's evaluation and interpretation of the results, case study organisation's top management feedback on the ranking of the projects, the lessons learned from the arduous data collection journey and what can be done in the future to make it easier. Also, a second look at the correlation results without considering the complexity factor to identify its impact on project success is undertaken. Then the role of various KPIs in the PDS scores and overall success are discussed, followed by investigations on what could have been done in the case study projects to achieve better PDS scores and more successful outcomes, and finally, the role of a PMO that could help project managers achieve better project performance is explained.

5.2 RANKING OF PROJECTS

The case study projects are ranked based on the PDS scores as described in the previous chapter. These scores can be seen in Table 20, along with the KPIs computed for each project. The dataset includes key information from 34 projects spanning from 5 to 66 months and representing various project types ranging from office renovation to large hospitals and institutional buildings. Of these projects, 14 are considered successful because of their non-negative PDS score. This ranking is generated using the planned and actual data from the projects, requiring some subjective judgement and support from the senior management, which is discussed in the next section.

Table 20. Ranking of the Case Study Projects

			Scope (various units)		Cost (AUD)		Time (Months)		Risk (MRL)		Key Performance Indicators (KPIs)						Triple Bottom Line (TBL)			
Project Number	**Ranking**	**PDS**	*Planned*	*Actual*	*Planned*	*Actual*	*Planned*	*Actual*	*Planned*	*Actual*	*value*	*efficiency*	*speed*	*innovation*	*complication*	*impact*	*profit*	*people*	*planet*	*progress*
CS#13	1	31.00%	1,760.00	1,760.00	$5,285,590	$4,952,212	7.00	7.00	2.57	2.09	6.73%	-6.31%	0.00%	-13.27%	23.06%	23.06%	13.92%	0.00%	51.43%	21.78%
CS#5	2	26.00%	450.00	480.00	$6,300,000	$6,900,000	18.00	12.00	2.11	2.56	-2.61%	64.29%	60.00%	10.56%	-44.94%	-11.91%	-5.15%	156.00%	-22.40%	42.82%
CS#17	3	25.00%	1,100.00	1,100.00	$5,000,000	$5,000,000	10.00	10.00	2.45	1.73	0.00%	0.00%	0.00%	-29.29%	41.42%	41.42%	0.00%	0.00%	100.00%	33.33%
CS#8	4	17.00%	42,000.00	53,000.00	$360,000,000	$517,000,000	24.00	26.00	1.99	2.10	-12.13%	32.56%	16.48%	-26.42%	2.53%	19.43%	-22.79%	35.68%	42.63%	18.51%
CS#23	5	17.00%	50,000.00	50,000.00	$45,000,000	$40,000,000	23.00	24.50	2.42	2.24	12.50%	-16.55%	-6.12%	4.01%	15.22%	8.17%	26.56%	-11.87%	17.00%	10.56%
CS#12	6	16.00%	153.00	153.00	$32,000,000	$33,000,000	30.00	30.00	2.24	1.73	-3.03%	3.13%	0.00%	-24.89%	29.10%	29.10%	-5.97%	0.00%	66.67%	20.23%
CS#20	7	10.00%	5,000.00	5,000.00	$2,000,000	$2,000,000	5.00	5.00	2.20	2.00	0.00%	0.00%	0.00%	-9.09%	10.00%	10.00%	0.00%	0.00%	21.00%	7.00%
CS#22	8	9.00%	4,000.00	4,000.00	$4,000,000	$4,000,000	11.00	11.00	1.95	1.79	0.00%	0.00%	0.00%	-8.23%	8.97%	8.97%	0.00%	0.00%	18.75%	6.25%
CS#15	9	8.00%	75,000.00	75,000.00	$55,000,000	$55,000,000	48.00	48.00	2.65	2.45	0.00%	0.00%	0.00%	-7.42%	8.01%	8.01%	0.00%	0.00%	16.67%	5.56%
CS#7	10	4.00%	4,800.00	4,800.00	$20,000,000	$18,000,000	9.00	10.00	2.76	2.66	11.11%	-19.00%	-10.00%	7.09%	15.29%	3.76%	23.46%	-19.00%	7.66%	4.04%
CS#9	11	0.00%	22,500.00	22,500.00	$230,000,000	$230,000,000	60.00	66.00	2.21	2.00	0.00%	-9.09%	-9.09%	-9.50%	21.55%	10.50%	0.00%	-17.36%	22.10%	1.58%
CS#11	12	0.00%	10,500.00	10,500.00	$82,000,000	$82,000,000	30.00	42.00	2.24	1.73	0.00%	-28.57%	-28.57%	-22.54%	80.74%	29.10%	0.00%	-48.98%	66.67%	5.90%
CS#18	13	0.00%	40,000.00	40,000.00	$75,000,000	$70,000,000	24.00	27.00	2.65	2.45	7.14%	-17.04%	-11.11%	-0.80%	21.51%	8.01%	14.80%	-20.99%	16.67%	3.49%
CS#21	14	0.00%	3.00	3.00	$2,000,000	$2,600,000	5.00	5.00	2.65	2.24	-23.08%	30.00%	0.00%	-34.99%	18.32%	18.32%	-40.83%	0.00%	40.00%	-0.28%
CS#29	15	-1.00%	2,700.00	2,700.00	$13,000,000	$15,329,280	16.00	14.00	2.12	2.24	-15.19%	34.76%	14.29%	-10.61%	-16.99%	-5.13%	-28.08%	30.61%	-10.00%	-2.49%
CS#37	16	-1.00%	4.00	4.00	$2,480,987	$2,618,889	5.00	6.00	2.51	2.00	-5.27%	-12.03%	-16.67%	-24.51%	50.60%	25.50%	-10.25%	-30.56%	57.50%	5.56%
CS#6	17	-4.00%	52.00	52.00	$3,330,000	$3,390,000	7.00	10.00	1.50	1.11	-1.77%	-28.74%	-30.00%	-27.31%	93.05%	35.14%	-3.51%	-51.00%	82.62%	9.37%
CS#16	18	-11.00%	7,700.00	7,700.00	$16,000,000	$16,000,000	24.00	24.00	2.00	2.24	0.00%	0.00%	0.00%	11.80%	-10.56%	-10.56%	0.00%	0.00%	-20.00%	-6.67%
CS#33	19	-12.00%	9,600.00	9,600.00	$20,560,000	$21,267,673	35.00	36.00	1.96	2.45	-3.33%	0.57%	-2.78%	21.00%	-17.82%	-20.10%	-6.54%	-5.48%	-36.17%	-16.06%
CS#2	20	-15.00%	40.00	40.00	$400,000	$360,000	7.00	7.00	1.79	2.55	11.11%	-10.00%	0.00%	58.40%	-29.85%	-29.85%	23.46%	0.00%	-50.80%	-9.11%
CS#35	21	-18.00%	864.00	864.00	$6,600,000	$6,600,000	30.00	30.00	1.87	2.45	0.00%	0.00%	0.00%	30.96%	-23.64%	-23.64%	0.00%	0.00%	-41.70%	-13.90%
CS#36	22	-19.00%	5,760.00	5,760.00	$17,500,000	$17,500,000	15.00	22.00	2.64	2.64	0.00%	-31.82%	-31.82%	0.00%	46.67%	0.00%	0.00%	-53.51%	0.00%	-17.84%
CS#10	23	-23.00%	2,700.00	2,700.00	$8,300,000	$8,300,000	12.00	12.00	1.73	2.24	0.00%	0.00%	0.00%	29.10%	-22.54%	-22.54%	0.00%	0.00%	-40.00%	-13.33%
CS#4	24	-25.00%	150.00	150.00	$750,000	$750,000	7.00	7.00	1.86	2.58	0.00%	0.00%	0.00%	38.64%	-27.87%	-27.87%	0.00%	0.00%	-47.98%	-15.99%
CS#26	25	-27.00%	750.00	750.00	$43,400,000	$39,435,000	21.00	24.00	2.00	2.54	10.05%	-20.49%	-12.50%	39.77%	-10.01%	-21.26%	21.12%	-23.44%	-38.00%	-13.44%
CS#28	26	-27.00%	46.00	46.00	$52,000,000	$60,000,000	26.00	35.00	1.58	2.92	-13.33%	-14.29%	-25.71%	59.81%	-26.99%	-45.77%	-24.89%	-44.82%	-70.59%	-46.76%
CS#38	27	-29.00%	1,500.00	1,500.00	$17,000,000	$19,800,000	7.00	12.00	2.08	2.12	-14.14%	-32.06%	-41.67%	-12.49%	68.19%	-1.89%	-26.28%	-65.97%	-3.74%	-32.00%
CS#3	28	-30.00%	50.00	50.00	$450,000	$500,000	7.00	8.00	1.83	2.05	-10.00%	-2.78%	-12.50%	0.82%	2.02%	-10.73%	-19.00%	-23.44%	-20.31%	-20.92%
CS#14	29	-30.00%	9,500.00	10,450.00	$37,000,000	$43,000,000	15.00	22.00	2.24	2.24	-5.35%	-20.76%	-25.00%	-13.95%	46.67%	10.00%	-10.41%	-43.75%	21.00%	-11.05%
CS#40	30	-33.00%	2,000.00	2,000.00	$2,830,652	$2,830,652	11.00	12.00	1.73	2.54	0.00%	-8.33%	-8.33%	46.82%	-25.70%	-31.89%	0.00%	-15.97%	-53.61%	-23.19%
CS#24	31	-34.00%	1,600.00	1,600.00	$40,800,000	$42,100,000	20.00	26.00	2.65	3.00	-3.09%	-20.63%	-23.08%	9.89%	14.65%	-11.81%	-6.08%	-40.83%	-22.22%	-23.04%
CS#30	32	-41.00%	300.00	300.00	$26,600,000	$29,465,691	15.00	21.00	1.58	2.74	-9.73%	-20.88%	-28.57%	56.36%	-19.17%	-42.26%	-18.51%	-48.98%	-66.67%	-44.72%
CS#39	33	-41.00%	25.00	25.00	$22,100,000	$22,100,000	39.00	50.00	1.68	2.23	0.00%	-22.00%	-22.00%	32.74%	-3.41%	-24.66%	0.00%	-39.16%	-43.24%	-27.47%
CS#19	34	-43.00%	500.00	500.00	$500,000	$500,000	6.00	9.00	2.24	2.83	0.00%	-33.33%	-33.33%	26.49%	18.59%	-20.94%	0.00%	-55.56%	-37.50%	-31.02%

5.3 FEEDBACK FROM SENIOR MANAGERS

Once the results were finalised, the researcher sought feedback (i.e. formal letter) from the director of the collaborating organisation on both the results and project rankings (Figure 35).

[redacted]

09 March 2020

[redacted]

Amir Ghanbaripour
Faculty of Society & Design
Bond University
Robina 4229 Queensland

For the attention of Amir Ghanbaripour

Dear Amir,

Bond University - Research Project

I would like to thank the research team at Bond University for their efforts in assisting us to better understand how we can maximise the performance of our projects and assess their success. It has been a long journey for you to collect all the information needed from our various projects across three States, both in terms of quantitative success factors and qualitative performance indicators.

We appreciate the professional and competent approach taken when working with our project managers.

Having reviewed the results, I am impressed with the ability of the 3D Integration Model to assess our projects in a consistent manner. It highlighted projects where performance was excellent, and also was able to identify projects that might have been further improved. I think that if we were using this approach during project execution, we would have an early warning system about potential success and be able to take timely action.

The model rated our projects using PDS in a very similar ranked order to what I would have done based on my experience as a Project Director with knowledge of the projects studied, and client feedback which I regularly receive. In addition, the strong correlation between PDS and PAR suggests to me that our processes can lead to successful outcomes when they are fully applied.

It is, however, a clear area of potential benefit for our organisation that we ensure lessons learned from past projects are formally recorded and recognised as a critical component for ongoing improvement. We need to do better at this.

I look forward to further conversations about how we can improve our service to clients, as well as to other stakeholders, through the wider *i3d3* model that the research team at Bond University has developed.

Yours faithfully

[redacted]

Figure 35. Letter Received from the Organisation's Director

A wide range of projects located in various parts of Australia (both regional and metropolitan areas) is collected. Although the PMs and the interviewed senior managers are different, all projects are run by a single project management consultancy. One of the regional directors with thorough knowledge of all their projects is asked to provide feedback on the results of the study. In order to acquire a realistic viewpoint and validate the ranking of the projects, face-to-face non-structured interviews are used to determine whether or not the ranking based on the PDS scores makes sense from the perception of top management and matches their experience with the projects. The Director of the collaborating organisation supports the research outcomes.

5.4 ISSUES WITH DATA CONFIDENCE

Empirical research includes the observation of knowledge, facts and evidence in the real world. For the general quality of research, the efficiency of data collection is critical (Carter & Fortune, 2004). The work adheres to the 'triangulation' principle, which is the use of multiple data collection methods or techniques, to make the findings more reliable. Other sources of information, such as documentation, the reporting from mass media and interactions with respondents are often used by researchers and can differ in formality from occasional conversations to interactive interviews and regular surveys (Denzin, 1989). In this regard, a case study organisation was required that had carried out many projects and was willing to exchange highly sensitive information from its projects. It took several months and was an arduous journey. The researcher approached various organisations that had stored the necessary data and had already carried out a variety of projects. This involves conference networking, contacts at professional associations, telephone calls, emails and video calls. In the end, only one organisation agreed to participate.

The researcher then scrutinised their project files to obtain the data and began to schedule interviews with the key people involved. First, there was a meeting between regional managers, executive assistants, the researcher and the research supervisor to begin the journey. Second, meetings with the various project managers who were responsible for delivery were held. The researcher could not risk the reliability of the study by interviewing people with second-hand knowledge. Each interview lasted at least one hour, and the first questionnaire was filled out using the project files that the project managers would bring to the meeting. Such files contained contract documents, letters, copies of e-mails, memoranda, minutes of meetings, budget reports, status reports, risk registers, and project charters. In order to obtain planned (start) and actual (finish) data for scope, cost, time and risk level, the project manager and researcher would have to review all the records. If the data could not be obtained or requested from other departments, the project managers would then send the filled-out questionnaire to the researcher via e-mail afterwards or another meeting would be held. Almost all project managers provided legitimate and reliable data on their projects. This included not only the CSFs, but also a number of useful comments on key issues that had occurred throughout the various project phases, a thorough explanation of project scope, stakeholders, uncertainty, latent conditions, detailed risk registers, project completion and start dates, and an opinion of customer satisfaction. In the latter case, there was a formal process of client feedback, but it was found to be not particularly enlightening, as all clients appeared to be equally satisfied.

This process would have been much quicker and more straightforward if the collaborating organisation had an effective PMO with all project records, risk registers and performance documents stored. The critical role of the PMO is discussed later in this chapter.

5.5 IMPACT OF COMPLEXITY

Project complexity is one of the most debated topics in the field of project management, perhaps second only to that of project success. Bakhshi et al. (2016) explored the historical development of project complexity. For the period 1990 to April 2015, they identify 783 publications related to complex projects, of which 423 specifically addressed project complexity. Over a period of 25 years, more than 125 different complexity factors are identified. The outcome of their review is shown in Figure 36 (Bakhshi et al., 2016).

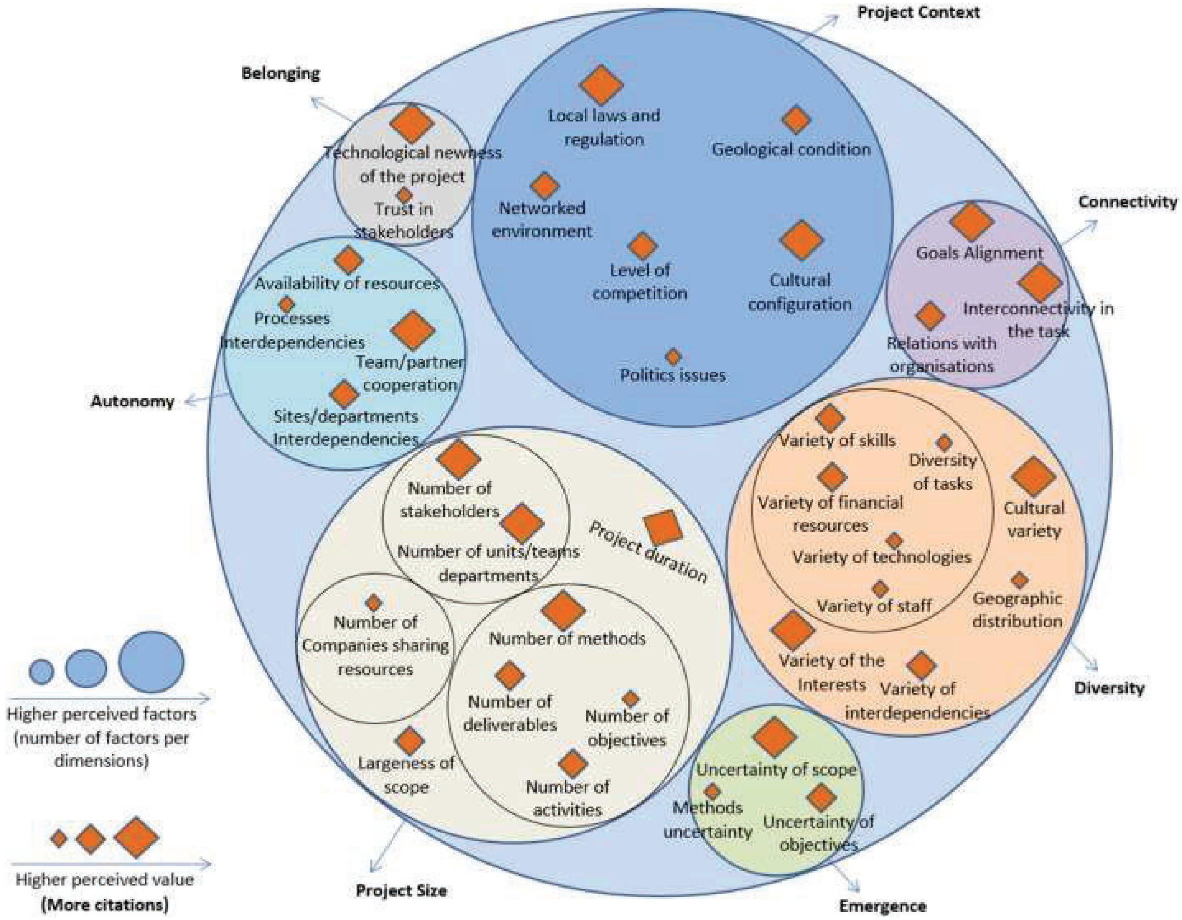


Figure 36. Primary Project Complexity Factors (Bakhshi et al., 2016)

The 3D integration model used in this study incorporates the CFC model introduced by Langston & Dhaduk (2019), which modifies the PDS scores of the projects and therefore affects the correlation between PDS and PAR scores. Some of the case study projects possessed high PDS scores but due to lower complexity levels, ended up with decreased scores. The same happened to some of the case studies with very low PDS scores.

For instance, the PDS score for case study #28, which was the construction of a medium-sized hospital, is -55% with very low KPIs such as impact (-46%), speed (-26%), complication (-27%) and efficiency (-14%). These are mostly because of a cost overrun of more than 15% and time overrun of nearly 35%, and a significant increase in the risk levels from 1.58 to 2.92. Figure 37 indicates the correlation between the PDS and PAR scores calculated without considering the complexity factor.

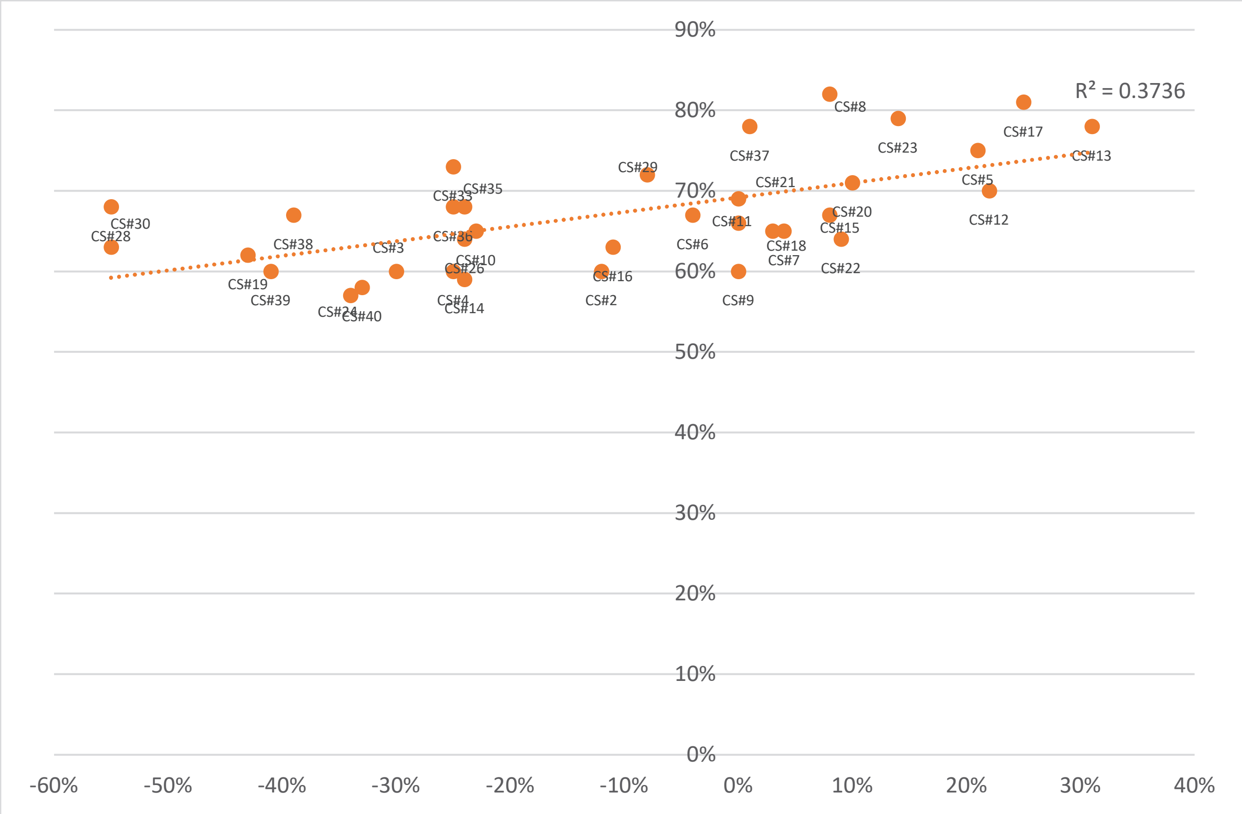


Figure 37. The PDS and PAR Scores' Correlation (complexity factor excluded)

Looking at the project data and the complexity index sheds some light on the reasons behind the unsuccessful outcomes. First, case study #28 suffered from several unknown risks during the construction phase, such as several latent conditions, scope changes due to numerous alteration requests from stakeholders, as well as design non-compliance that was not detected until construction started. In addition, this hospital, which needed to be extended and refurbished, was built more than 95 years ago and gave rise to a significant number of unexpected issues that were progressively uncovered during the construction process. This placed the project at a high level of uncertainty. Second, the extension and renovation work, which went for almost three years, was carried out while the hospital remained in operation. As noted by the project manager, a wide variety of project stakeholders were involved at each stage of the project, leading to a broad spectrum of requirements, changes and disputes. This also, in hindsight, put the project at a high level of complexity in terms of stakeholders. The model considers this project to be 'chaotic' and hence allows the PDS to improve to -27%.

Case study # 30 is another project that was impacted by the complexity factor. The project involves the renovation of a relatively large library to add 300 seats, new equipment and spaces to the existing building. The library was constructed more than 80 years ago, so the project included a significant number of latent conditions. The other major issue that increased the level of uncertainty and risk was that the project manager was only appointed during the construction phase of the project. All of these issues increased the project uncertainty index to 3, resulting in a high complexity factor that adjusted the PDS score upwards to -41%.

In contrast, after applying the complexity factor, the PDS score for case study #12 went down from 22% to 16% due to a fewer number of stakeholders getting involved in the decision-making process. The project had a low complexity factor.

5.6 CHARACTERISTICS OF SUCCESSFUL PROJECTS

In recent decades, interest in project delivery success has increased. This is linked to the marketing and reputational advantage that is achieved from successful projects, as recognised and awarded by industry bodies. More often than not, project delivery success is a subjective decision. However, it is well acknowledged that successful projects share some common characteristics (De Wit, 1986). These common qualities can, therefore, be used to some extent as ‘measures’ for the success of the project (Zuo et al., 2018). Case study # 13, case study # 5 and case study # 17 are the most successful projects on the list. Case study # 13 experienced a slight decrease in actual costs and moderately significant risk mitigation. Although the KPIs for efficiency and innovation do not show good results, the project has done a terrific job in terms of value, impact and complication.

Data analysis shows three KPIs, namely value, speed and, can have a significantly affect on project success.

Value:

As explained in Chapter 2, value is defined as the ratio of scope over cost (objective: maximise). Value is a function of project stakeholder management, namely meeting expectations and fostering engagement. The scope is treated as output and cost is treated as an input, so the more utility per unit of cost the greater is the value for money (Ghanbaripour et al., 2017). Figure 38 highlights that most successful projects (shown in blue) achieve a positive number for value (shown on the right hand side of the chart).

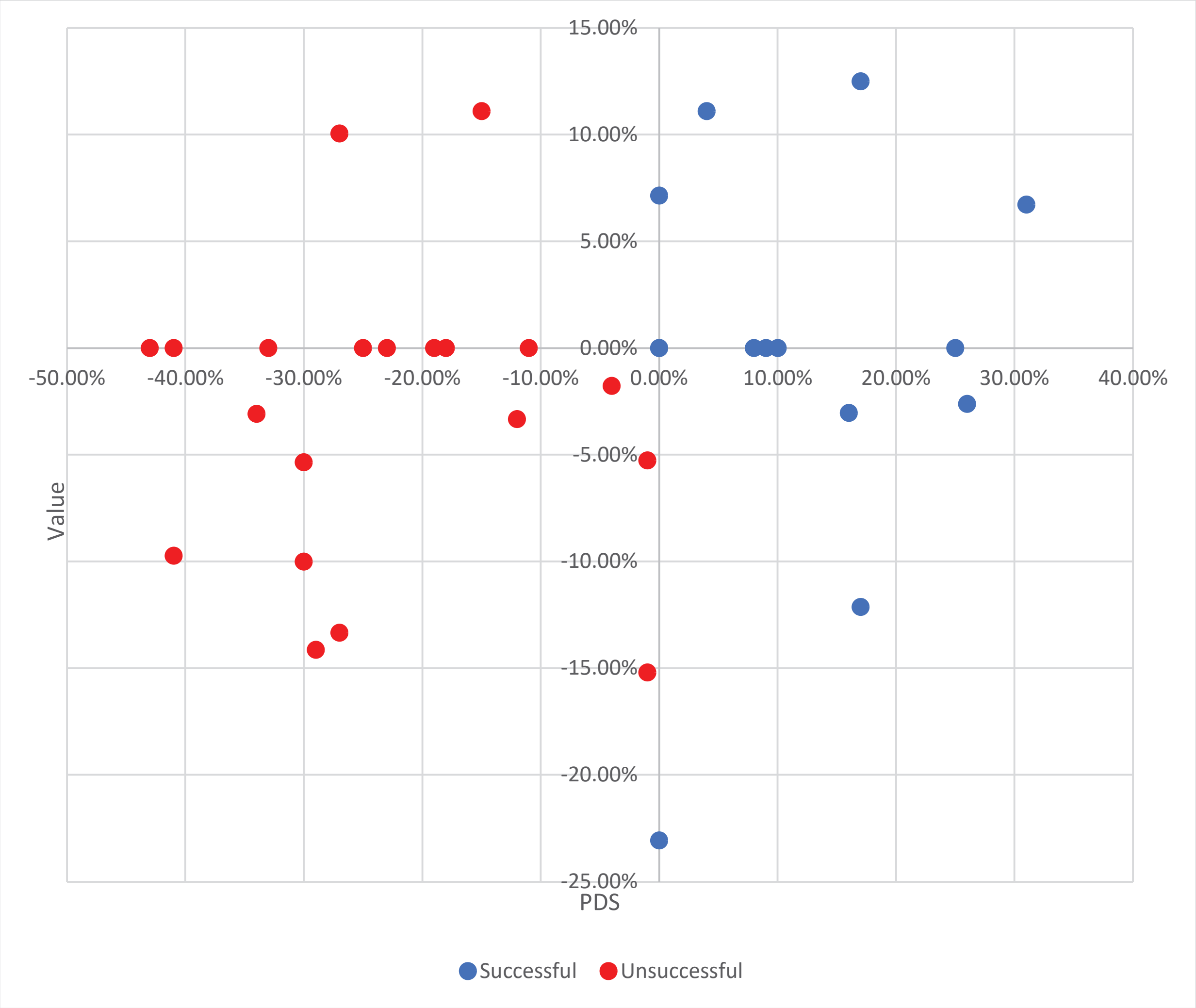
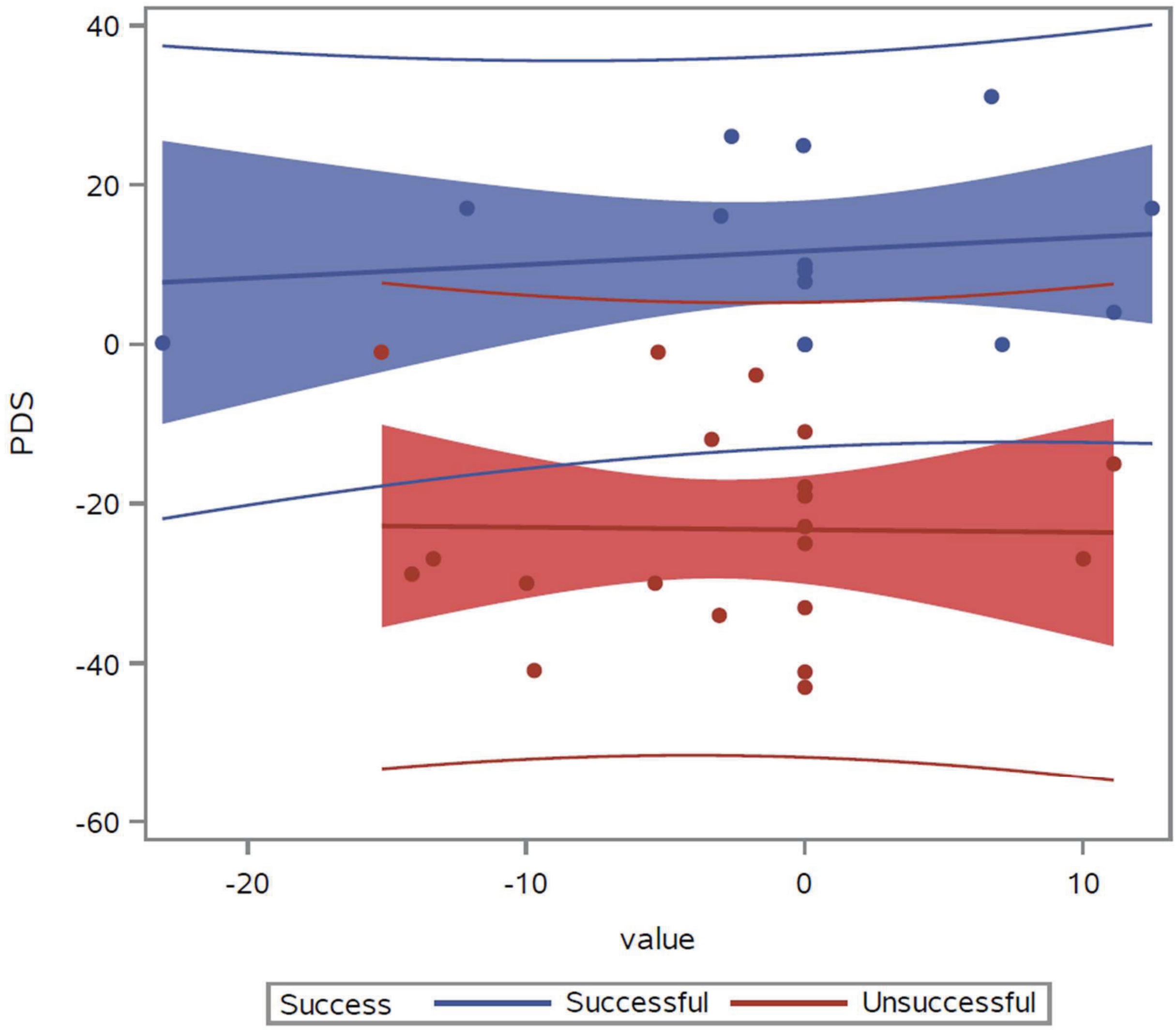


Figure 38. Value and PDS Scatter Diagram

This can also be seen in Figure 39, where there is a positive correlation between successful projects and PDS scores.



Note. Blue and red shades: 0.05 confidence limits of the regression coefficient, Blue and red lines out of shades: 0.05 confidence limits of prediction) - Overall R-square = 22% for All Projects (Successful and Unsuccessful)

Figure 39. Scatterplot and Regression Line between Value and PDS

Although there are a few unsuccessful projects on the positive side of the value spectrum, most of them are below zero. Looking at the planned and actual figures for the successful projects with positive values shows clearly that all of them delivered the expected scope of the project at a lower cost. This is also consistent with the literature and common sense in project management, suggesting the model does not produce PDS scores that are surprising.

Speed:

Once again, speed is defined as the ratio of scope over time (objective: maximise). Speed is a function of project procurement management, namely, outsourcing strategies and parallel supply chains. The scope is treated as output and time as an input, so the more utility provided per unit of time, the faster is the delivery process (Ghanbaripour et al., 2017). As can be seen in Figure 40, most of the projects on the positive side of the graph are successful (PDS≥0).

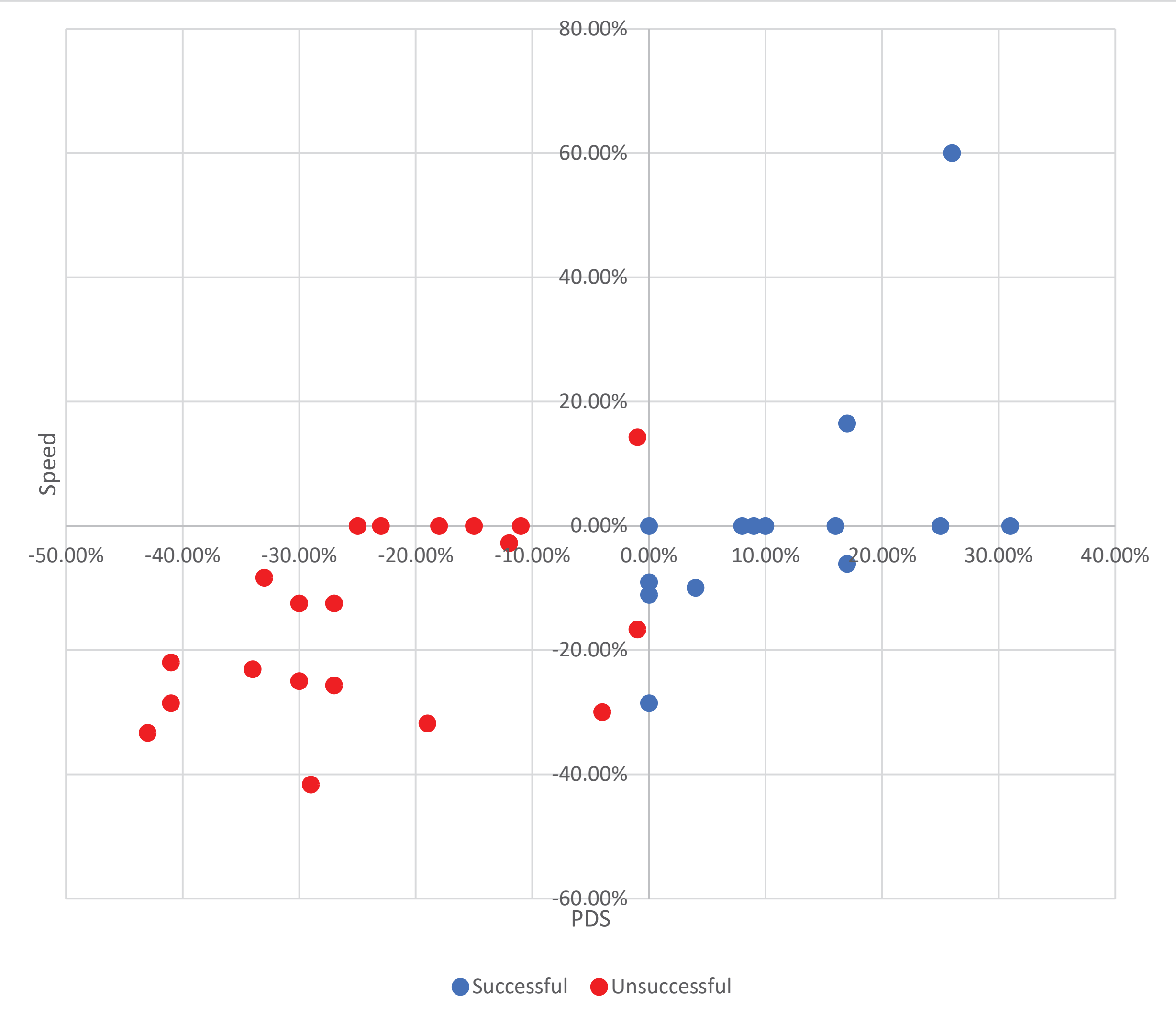
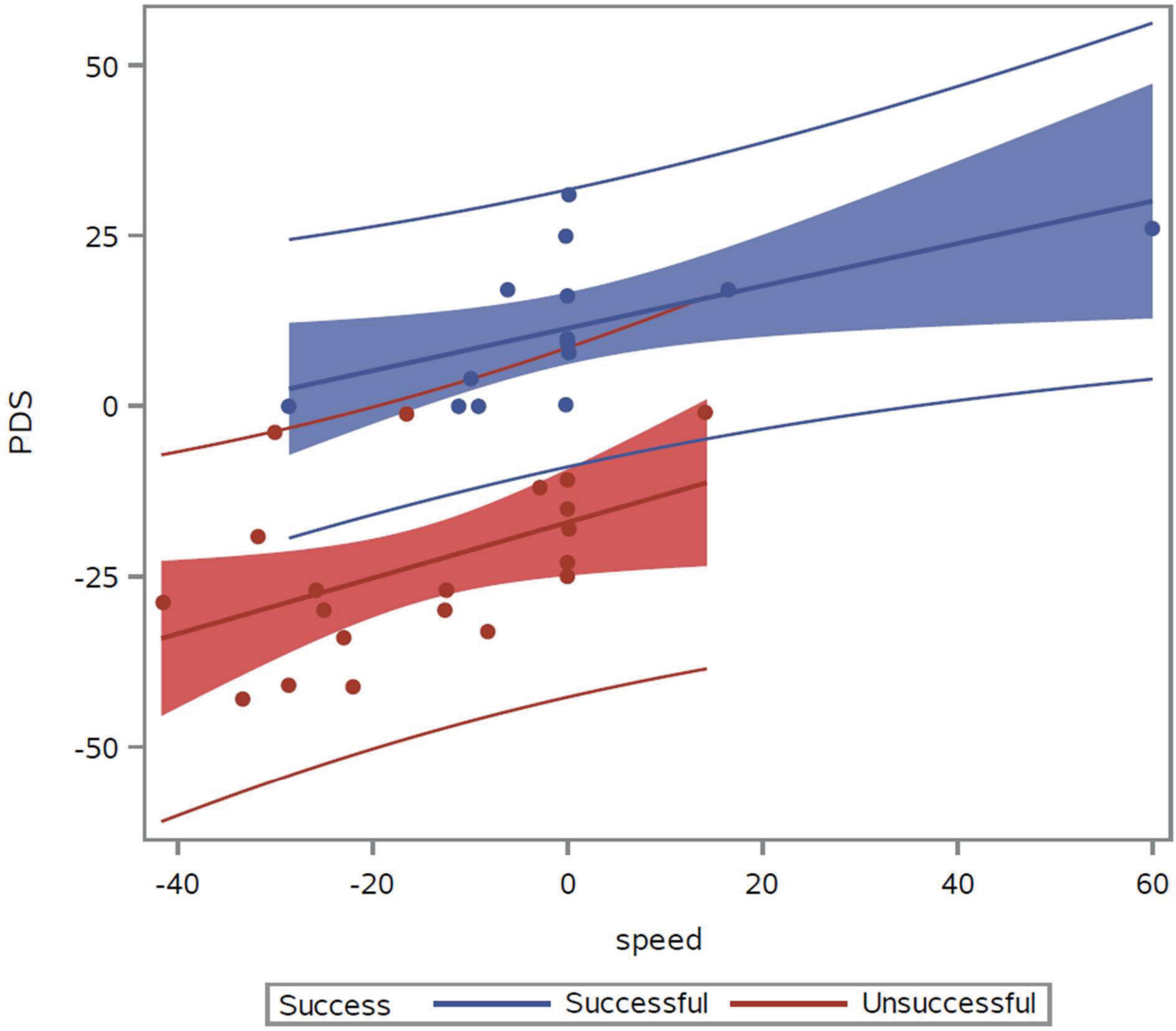


Figure 40. Scatter Diagram of the Case Studies based on the KPI of Speed and PDS

This suggests that completing projects faster can be a good strategy. The correlation between successful and unsuccessful project is provided in Figure 41.



Note. Overall R-square = 42% for All Projects.

Figure 41. Scatterplot and Regression Line between Speed and PDS

Key stakeholders, such as client, end-user and sponsor, are keen for projects to be delivered at the same or lower cost more quickly. It can be accomplished by focusing more on important activities, proper resourcing, more effective management of the supply chain, and so on.

Impact:

Impact is defined as the ratio of risk over scope (objective: *minimise*). It is a function of project environmental management, namely adverse sustainability outcomes and unnecessary resource consumption. Risk is treated as output and scope as an input, so a higher risk level per unit of utility reflects unwanted environmental disruption (Ghanbaripour et al., 2017). Project impact has traditionally been given a lower priority than cost, especially in the construction industry. Figure 42 and Figure 43 both reveal that successful projects are significantly better in terms of reducing their impact on the environment comparing to unsuccessful ones.

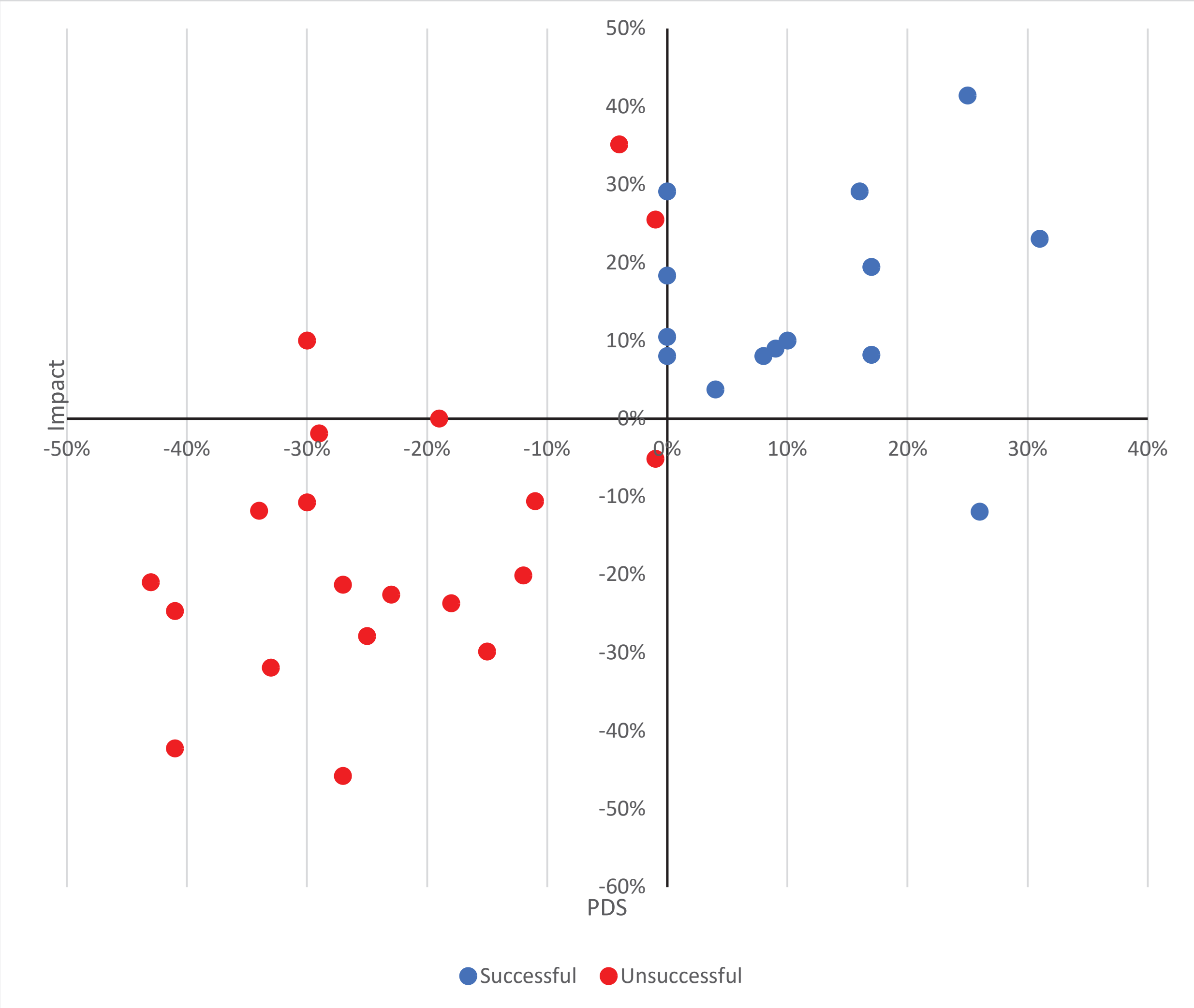
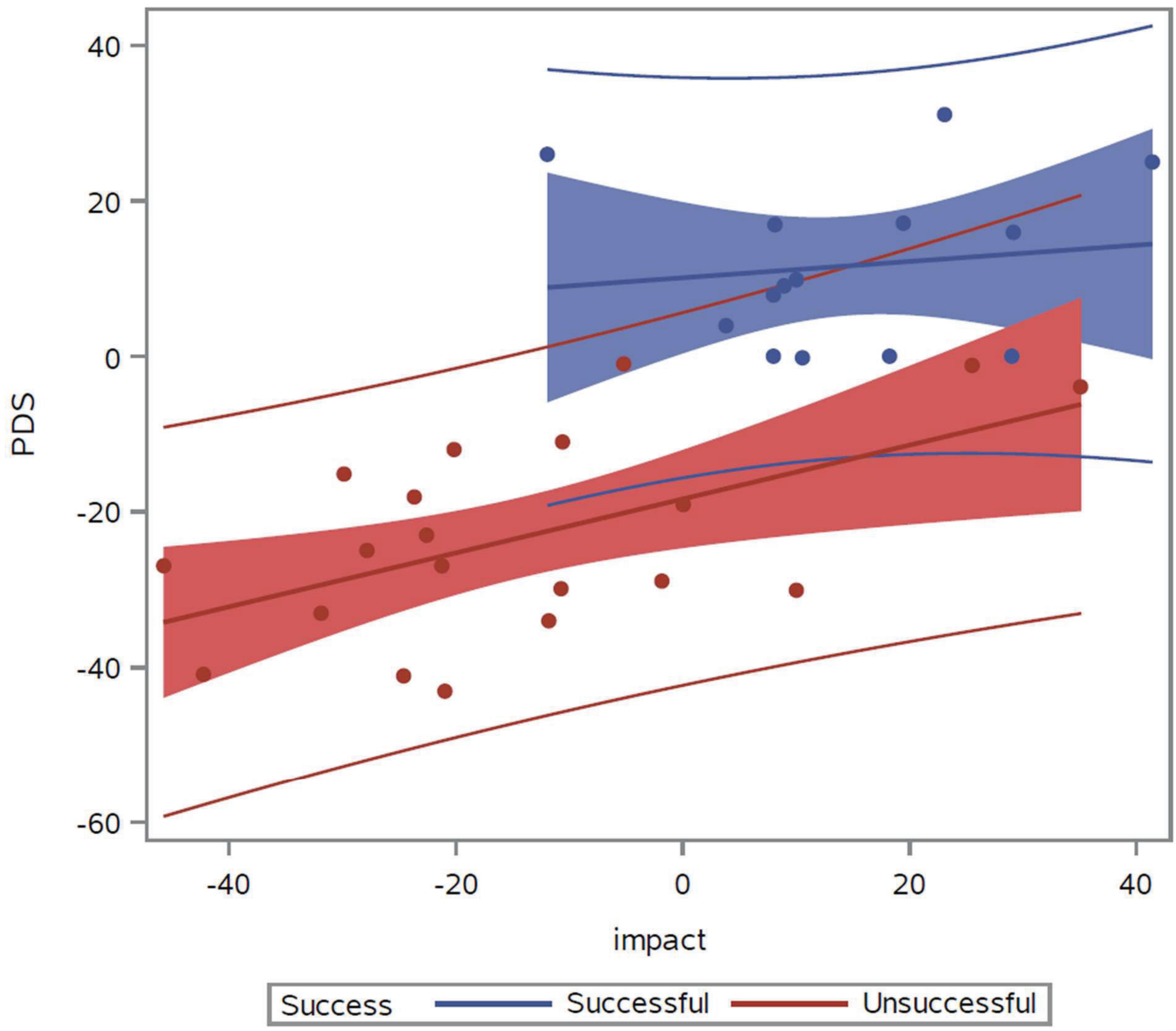


Figure 42. Impact and PDS Scatter Diagram



Note. Overall R-square = 34% for All Projects.

Figure 43. Scatterplot and Regression Line between Impact and PDS

Impact on the environment might include various factors such as fine particulates: mainly caused by the degradation of mineral construction materials, emissions into the air, use and contamination of land, use of natural resources and raw materials (including energy), local issues (noise, vibration, odour, dust, visual appearance, etc.), transport issues, risks of environmental accidents and effects arising, or likely to arise, as a consequence of incidents, accidents and potential emergency situations (Medineckiene et al., 2010).

Lowering the impact of projects could be challenging, especially in larger developments. The concept of sustainability is linked to economic, environmental and social dimensions and their interrelations, or TBL (Elkington, 1998; Martens & Carvalho, 2016), which is part of the 3D integration model's structure.

5.7 STRATEGIES FOR OPTIMISING THE PDS SCORE

So what strategy could project managers have taken to achieve more successful outcomes in these projects? In order to explore the various options that were available to the project team, case study #39 is chosen. This renovation project is carried out to construct a new 25-bed aged-care residential facility. Table 21 shows the current situation of this project.

Table 21. Case Study #39 Original Performance

Case study #39							
Scope		Cost		Time		Risk	
planned	*actual*	*planned*	*actual*	*planned*	*actual*	*planned*	*actual*
25	25	$22,100,000	$22,100,000	39	50	1.68	2.23
	KPIs						
value	✔	0.00%					
Efficiency		-22.00%					
speed		-22.00%		Profit		0.00%	
Innovation	✔	32.74%		People		-39.16%	
Complication		-3.41%		Planet		-43.24%	
Impact		-24.66%		Progress		-27.47%	
PDS		-41					

This project should be considered unsuccessful in terms of delivery due to the negative PDS score (-41) as well as the negative numbers for many KPIs. The project team delivered the project within the budget and provided the expected scope to the client. Time and risk are the factors that have negatively affected the success of the project. The project recorded the worst figure among all KPIs for impact and speed.

Looking at impact and the planned and actual risks, it is clear that many risks occurred during the project that could have been better managed by the project team in order to achieve a lower level of actual risk. The risk register cannot be shown here because of the confidentiality of the data. However, the researcher found that some risks related to delays and motivation of workers were identified in the planning phase that could have been mitigated, resulting in the achievement of a mean risk level of 1.87 and substantial improvements in KPIs. Also, the project team was unable to complete the work on time, leading to an 11-month delay. The progress score also indicates that the actual performance on site was classified as regressive and failed to assist the contributing objectives of profit, people and planet.

However, the model only indicates whether the project has been successful from the point of view of a delivery and does not take into account the customer, end-user and designer points of view. Perhaps the people now living in this aged-care facility love everything about it, or the designers believe that the new spaces meet all the architectural and contemporary requirements that can contribute to resident wellbeing and happiness. This highlights the need for a more comprehensive project success measurement tool, such as *i3d3*, to which the 3D integration model applies to just one of the three phases (deliver). No data are available to explore the design and delight phases, but in theory these might counterbalance the poor delivery score.

Assuming the value KPI was originally the main objective for this project, as can be witnessed in the optimised solution given in Table 22, cost would need to go down $200,000 below the original budget, delays would need to be restricted to no more than one month, the scope would need to go up to 26 beds using the savings found through deployment of a value management workshop with all the consultants, and risk would need to be restricted to 1.67. Here, profit, people, planet are quite balanced, and the project is now classified as progressive. A small increment in the scope (i.e. delivering a larger project function) could help the project team significantly in getting a more successful outcome (PDS=11).

Table 22. Case Study #39 Optimised Performance

Case study #39							
Scope		Cost		Time		Risk	
planned	*actual*	*planned*	*actual*	*planned*	*actual*	*planned*	*actual*
25	26	$22,100,000	$21,900,000	39	40	1.68	1.67
	KPIs						
value	✔	4.95%					
Efficiency		-3.38%					
speed	✔	1.40%		Profit		10.14%	
Innovation	✔	0.31%		People		2.82%	
Complication	✔	3.18%		Planet		9.46%	
Impact	✔	4.42%		Progress		7.47%	
PDS		11					

However, the aforementioned optimisation process might seem too optimistic, given the project's poor performance in schedule management. Assuming the project team were able to mitigate the risk level to 1.87, and even save $2 million off the project budget, they still would need to spend the saved money on increasing the scope to still achieve a positive PDS score and a progressive performance, as shown in Table 23.

Table 23. Case Study #39 Optimised Performance (with accepted delays)

Case study #39							
Scope		Cost		Time		Risk	
planned	*actual*	*planned*	*actual*	*planned*	*actual*	*planned*	*actual*
25	27	$22,100,000	$20,100,000	39	50	1.68	1.87
	KPIs						
value	✔	18.75%					
Efficiency		-29.06%					
speed	✔	-15.76%		Profit		41.01%	
Innovation	✔	22.39%		People		-29.04%	
Complication	✔	15.18%		Planet		-5.86%	
Impact	✔	-2.97%		Progress		2.04%	
PDS		3					

5.8 ROLE OF THE PMO

The combination of more projects and more complexity in the modern world of project management has led to the introduction of PMOs by many organisations seeking to improve supervision, coordination, and in many cases, more mature organisational structures and systems (Artto et al., 2011; Martins & Martins, 2012; Singh et al., 2009; Ward & Daniel, 2013). The trend across PMOs, according to Andersen et al. (2007, p. 98), is to facilitate '*systematic coordination and unified handling of key project-related tasks,'* so that organisations can be more effective over time.

A lack of successful project planning and budgeting, weak coordination and knowledge sharing procedures, insufficient reuse of previous experiences and learned lessons, and inadequate technical understanding, are some of the primary reasons for project failures. Other common factors are poor organisational performance, lack of systematic monitoring and lack of functional user involvement. The final result is cost and time overruns, rework or even abandoned projects prior to completion (Desouza & Evaristo, 2006).

Looking at the PDS scores that the collaborating organisation has achieved (see Figure 44), over the course of ten years from 2009 to 2019, it can be deduced that although the organisation has been highly successful in terms of signing more contracts with more new customers and undertaking more projects, the overall success rate has decreased significantly over time. This could be due to many reasons that an effective PMO might have prevented.

According to organisation's director, the main reason could be not establishing a proper procedure in the recording and continuous improvement of lessons learned from previous projects to improve new ones. The collaborating organisation does not have a formal PMO.

Several projects in the dataset are similar. For instance, case study #7 and case study #38 are government projects that were delivered under the same type of contract in 2014 and 2018 respectively. Many other similar projects were also completed in this 4-year timeframe. However, there is a 33% reduction in the PDS score of case study #38 comparing to case study #7. The risk level reduced with proper risk management in case study #7, but an increment occurred between planned and actual risk levels in case study #38. This clearly implies, as Cleland & Ireland (2008) and Williams (2007) demonstrated a decade earlier, the problem of learning from previous projects in a project-based organisation still exists. Even if these lessons are appropriately documented, project managers may not have the same experiences and rarely review feedback from others at the planning stage of new projects. Many of the challenges faced in case study #7 might have reoccurred in case study #38.

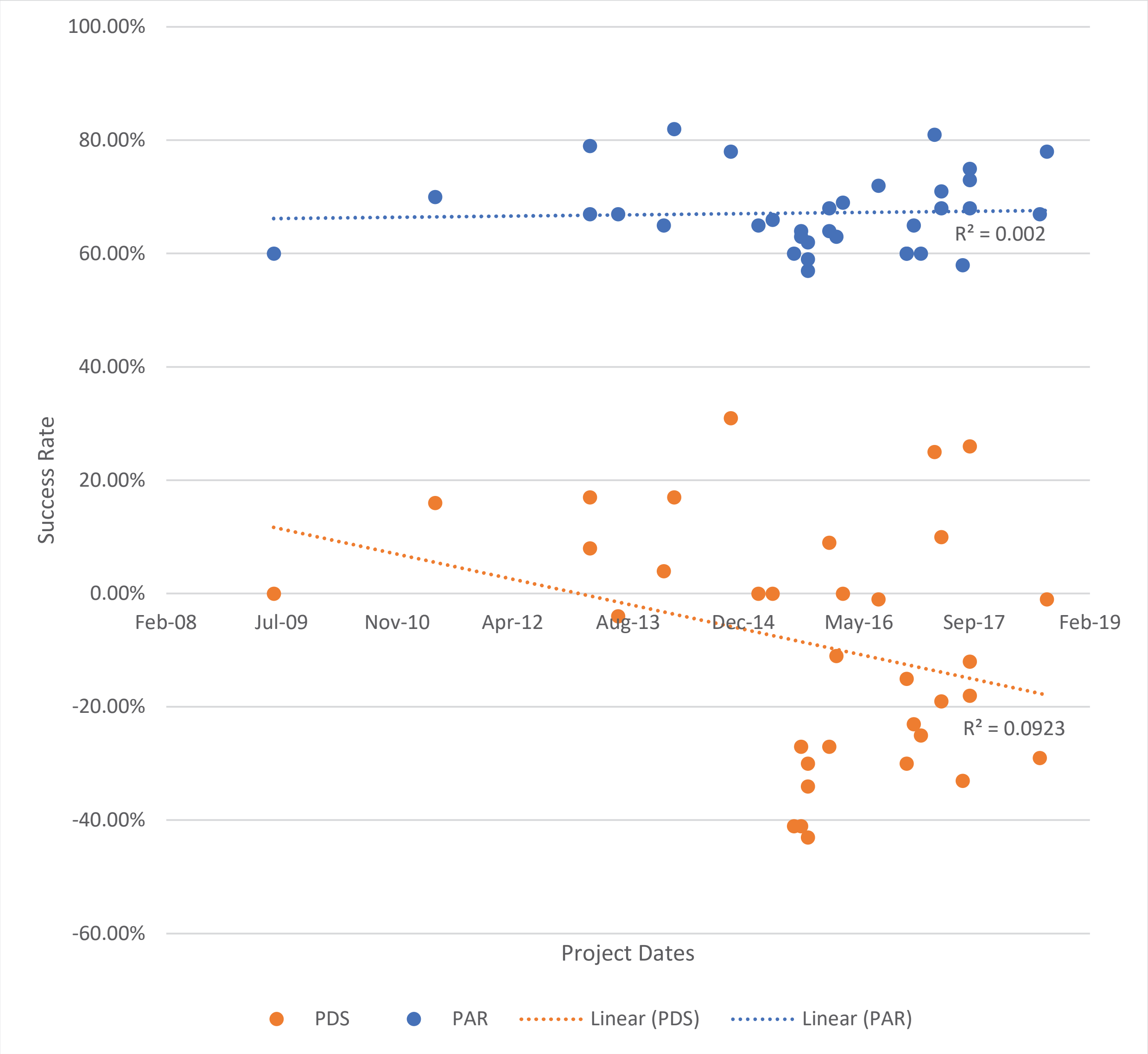


Figure 44. PDS and PAR over Time (based on commencement date)

Figure 44 also illustrates that the PAR scores for the collaborating organisation have not significantly improved over time. It means that in the eyes of the senior managers, the project managers are still implementing project management processes in the same way they did ten years ago. This is again related to the role of the PMO, implying that the company may have not invested in professional development training and/or new software tools and technologies. Ideally, the PAR score should increase over time through regular training opportunities, which the literature shows is one of the essential responsibilities of a PMO (Dai & Wells, 2004; Pemsel & Wiewiora, 2013).

5.9 EARNED VALUE ANALYSIS (EVA) VS. PROJECT DELIVERY SUCCESS (PDS)

Earned value analysis (EVA) was invented in 1967 as a technique to holistically evaluate the impact of cost and time performance at any point during project delivery. It has been widely used by project managers ever since (Anbari, 2004; Batselier & Vanhoucke, 2015; Fleming & Koppelman, 2012; PMI, 2017; Vanhoucke, 2014). It operates at the level of schedule tasks (representing the decomposition of project scope) using a number of inputs, outputs and forecasting tools, as follows:

Inputs:

- Budget at completion (BAC)
- Planned Value (PV)
- Earned Value (EV)
- Actual Cost (AC)

Outputs:

- Schedule Variance (SV) = EV – PV
- Schedule Performance Index (SPI) = EV / PV
- Cost Variance (CV) = EV – AC
- Cost Performance Index (CPI) = EV / AC

Forecasting Tools:

- Estimate to Complete (ETC) = (BAC – EV) / CPI
- Estimate at Completion (EAC) = AC + (BAC – EV)
- Variance at Completion (VAC) = BAC – EAC
- To Complete Performance index (TCPI) = (BAC – EV) / (BAC – AC)

BAC is the planned cost upon completion, PV is the budgeted amount through the current reporting period (e.g. end of Month 1), EV is the total budget multiplied by the percentage of scope completion, and AC is the actual costs to date.

SV = 0 means on schedule, while SV < 0 means behind schedule and SV > 0 means ahead of schedule, while SPI shows the variance. Similarly, CV = 0 means on budget, while CV < 0 means over budget and CV > 0 means under budget, while CPI shows the variance. SPI = 1 or CPI = 1 means no variance.

There are a number of commonalities between the computation of PDS, and EVA. Both compare planned and actual performance. Both can be applied at any time during project delivery, not just at completion when it is too late to address any problems. Good and bad outcomes can be easily identified using both techniques, including the single variable of TCPI in the case of EVA. Both are dependant on reliable input data and can be tracked over time.

However, there are also differences. EVA normally operates at the level of schedule tasks and is accumulated across all tasks, while PDS applies at the level of an entire project and is not reliant on a schedule or critical path. PDS focuses on project success, whereas EVA focuses on integrated cost and time performance. PDS includes an assessment of risk management and project complexity, whereas EVA formally does not. Finally, PDS provides an opportunity to test proposed strategies to improve performance and ensure a successful outcome at an early stage.

Figure 45 uses a hypothetical example of a landscaped garden project to demonstrate that PDS can replace EVA as a performance evaluation tool. Ignoring risk and complexity, the advice between the two techniques is consistent. At Day 10 (halfway point), PDS is -21 largely because delivered (actual) scope is behind plan. Given that $12,000 has been spent on just 100 out of 250 m2 of garden area, a forecast of completion suggests a revised budget of $30,000 (equal to AC + ETC). Likewise, a revised duration of 25 days is required based on current production rates. Should this unfold, a PDS of -31 will occur upon completion. Complexity was set at 8 out of 27 so it did not affect PDS scores.

Using TCPI of 1.15385 (i.e. 15.385% headwind), PDS shows equal forecasted cost and time outcomes at completion and an overall score of -25. Therefore, regardless of the choice of forecasting method, should remedial action not be taken immediately then the project will be counted as unsuccessful.

The use of PDS enables proposed strategies for improving performance to be tested. Three possible responses are presented to get back on track. Response #1 is based on cost equal to EAC ($27,000). In this case, the project can be successful (PDS = 3) if it can also be completed in a total of 18 working days. Response #2 is based on cost equal to ETC ($30,000). In this case, the project can be successful (PDS = 4) if it can also be completed in a total of 16 working days. Finally, Response #3 is based on time equivalent to EV (25 days). In this case, the project can be successful (PDS = 0) if it can also be completed for a total of $20,000.

A progress check using PDS can update the risk status for a project via an assessment of a range of risk events according to probability and consequence. For example, a new risk might have occurred and need to be added, or an existing risk might have been resolved. A lower risk score improves success, and vice versa. Change in risk often translates to a corresponding change in cost and/or time and may help explain the reason behind any performance variances.

The use of EVA at the schedule task level can still assist by providing reliable cost and time data that can be accumulated to the project level. In the example provided here, the project was assumed to be equivalent to a single task. Complexity does not change during project delivery, so can be ignored.

EXAMPLE: PROGRESS CHECK USING i3d3 MODEL

How to get back on track?

DELIVER: OVERALL PROJECT PLAN	*Landscaped Garden Project*	PROGRESS AT DAY 10 *Planned*	*Actual*	*Score*	FORECAST COMPLETION *Planned*	*Actual*	*Score*	POSSIBLE RESPONSE #1 *Planned*	*Actual*	*Score*
COST	$25,000 contract	12500	12000	17	25000	30000	-73	25000	27000	-23
TIME	20 working days	10	10	0	20	25	-61	20	18	35
SCOPE	250 m^2 garden area	125	100	-100	250	250	0	250	250	0
RISK*	1.73 (√ mean 1-3)	1.73	1.73	0	1.73	1.73	0	1.73	1.73	0
PDS	-100 ≤ PDS ≤ 100			**-21**			**-33**			**3**

Forecast completion: ^ BASED ON ACTUAL SCOPE (cost equivalent to AC + ETC)

Possible response #1: ^ BASED ON EAC (non-recurring problems)

The project is assessed at its halfway point. Due to poor workmanship, some garden areas had to be redone at the contractor's expense, which delayed progress on the project compared with its original plan. At Day 10, the project is clearly in trouble despite appearing to still be within budget expectations.

	POSSIBLE RESPONSE #2 *Planned*	*Actual*	*Score*
COST	25000	30000	-33
TIME	20	16	50
SCOPE	250	250	0
RISK*	1.73	1.73	0
PDS			**4**

^ BASED ON ETC (same expenditure rate)

	FORECAST COMPLETION *Planned*	*Actual*	*Score*	POSSIBLE RESPONSE #3 *Planned*	*Actual*	*Score*
COST	25000	28846.15	-50	25000	20000	0
TIME	20	23.08	-50	20	25	0
SCOPE	250	250	0	250	250	0
RISK*	1.73	1.73	0	1.73	1.73	0
PDS			**-25**			**0**

Forecast completion: ^ BASED ON TCPI (equalised performance rate)

Possible response #3: ^ BASED ON EV (same production rate)

= target (new)

*risk assumed unchanged

EXAMPLE: PROGRESS CHECK USING EARNED VALUE

Earned value analysis is usually performed at the task level of the project schedule. Here, it is assumed only one task exists.

TODAY	BAC	PV	EV	AC	SV	SPI	CV	CPI	ETC	EAC	VAC	TCPI
Day 10	25000	12500	10000	12000	-2500	0.80	-2000	0.83	18000	27000	-2000	1.15385

Figure 45. Comparing PDS and EVA on a Hypothetical Project

5.10 CONCLUDING REMARKS

This chapter interprets and discusses the results of the study. Projects are ranked based on the PDS scores, along with other values such as KPIs and the complexity factor. Before the findings were analysed, rankings were shown to the director of the collaborating organisation in order to verify the results as someone having oversight across the dataset. The issues faced by the investigator in the data collection process are explored, followed by an examination of the impact of the complexity factor on the PDS scores and the overall findings. The results are as expected and demonstrate that incorporating the complexity factor enables the model to generate more reliable and accurate output.

By looking at the qualities of the successful projects in the list, it is shown that three KPIs, comprising speed, value and impact, have considerable influence on the success of projects, leading to a number of recommendations for practitioners to improve their efficiency into the future.

The role of the PMO is investigated in this section by analysing the trend in the success rate over ten years of project management in the collaborating organisation. According to the letter from the director, the absence of a established and effective PMO and the lack of continuous improvement through access to lessons learned on past projects might be the main reason for relatively poor performance over time. The climax of this chapter is the comparison of the EVA and PDS, suggesting that the 3D integration model could be a robust replacement for this method and could be more accurate in predicting future performance. EVA is currently in use worldwide.

Chapter 6 provides an overall overview of the research and conclusions based on the results and findings of the analysis of the data. It describes the major quantitative and qualitative findings, and makes some recommendations and clarifies the future directions of research and the potential implications for practice.

CHAPTER 6: CONCLUSION

6.1 THE PURPOSE OF THIS CHAPTER

This chapter provides a concise overview of the previous chapters of the study and reflects on the aim and objectives set out in Chapter 1. The key findings of the study are also explored and discussed. Possibilities for further research and implications for practice are highlighted, including how adoption of the 3D integration model within the novel *i3d3* framework can be effectively disseminated.

6.2 KEY FINDINGS

The key findings of this research are as follows:

- The 3D integration model, first introduced in Langston (2013), is extended, tested and validated using project data from 40 various types of infrastructure projects, of different sizes, in diverse locations across Australia and with completion dates ranging between June 2009 and August 2018. Projects are compared and ranked on the basis of their success score. Quantitative and qualitative analysis indicates a strong positive correlation between PDS and PAR, and the findings are triangulated via the opinion of the director of the collaborating organisation who has independent oversight responsibilities (equivalent to a PMO). The findings demonstrate that the model is precise, robust and realistic, and therefore is ideal for assessing success for future projects irrespective of scale, location and date. Although various types of infrastructure projects is the focus of this study, there is no obvious reason why the same approach can’t be employed on any type of project. This is why the 3D integration model is now part of the *i3d3* model completed in 2020 (freely available at https://bond.edu.au/cccr).

- Three key KPIs, being value, speed and impact, are shown to have influence on the success of a project than any of the other KPIs. It is suggested that the project managers concentrate more on these aspects in order to maximise the likelihood of success in their projects. These three KPIs, unsurprising perhaps, show the highest correlation with the PDS rank. Hence, if the project manager is able to deliver more scope around the same level of expense, and complete project activities more rapidly while minimising adverse environmental impacts, it follows that they may significantly increase the likelihood of delivery success. It makes sense that doing more (scope) for less (cost, time and risk) leads to better outcomes – and more satisfied clients.
- Incorporating a complexity factor into the model smooths the PDS scores due to the difficulty of the challenge that lies ahead, as assessed by the scale of the project, the extent of uncertainty, and the diversity of stakeholders. This inclusion helps the model to produce more realistic and accurate results. The complexity score is akin to high platform diving in that the level of difficulty of the dive chosen factors into a diver’s final score. Where chaotic or high complexity potential is expected, any negative success factor is adjusted to 50% or 75% of its normal value (respectively). Where simple or low complexity potential is expected, any positive success factor is adjusted to 50% or 75% of its normal value (respectively).
- The application of PDS is not restricted to assessing the success of a project in hindsight. PDS can replace EVA as a mechanism to ensure that a project is on track at interim stages of the delivery process. Both techniques compare planned and actual performance, but PDS additionally considers the impact of changes in project scope and risk profile. Given EVA is used widely in practice, the likely uptake of modelling project delivery success is enhanced by this extra benefit. It also ensures that decisions taken during project delivery are aligned with the criteria used to evaluate the team’s performance, rather than working at odds to it. PDS scores can be tracked over time to

show the difference between planned and actual status, except that now there are two more ‘levers’ that can be used to initiate change.

6.3 REVIEW OF RESEARCH AIM AND OBJECTIVES

A variety of objectives are outlined in this analysis to jointly fulfil the overarching research question of:

> *'Does the ranking of projects according to PDS provide useful insight for project management consultancy practice in Australia to systematically improve its implementation performance?* '.

These objectives and how they were met at the different stages of the research project are explored in this sub-section.

Objective 1 – Systematically review the literature on project success and the challenges practitioners face in the Australian construction industry:

A systematic literature review is undertaken in this study, demonstrating that the concept of effective project delivery success has yet to be agreed upon, so there remains a great deal of doubt as to what success actually looks like. Despite the numerous studies on this topic, there is still no consensus on a consistent set of performance metrics or on a practical project success model. What is clear, however, is that there is a difference between project success and project management success, that various stakeholder groups hold sway at different phases of the project life cycle, that projects do not end at handover to the client, and that being able to compare and rank performance for any type of project (agnostic to its size, location or date) represents ‘the holy grail’ of measuring success.

Since the focus of this study is the Australian construction industry, the literature is also analysed to examine the success of the projects in this sector. The construction sector is one of the biggest employers in the country, making a significant contribution to the national economy and underpinning nearly all other sectors. This research, therefore, emphasises the urgent need for an agreed approach to assessing success of construction projects, because failures in these large and expensive developments results in lost prosperity for Australia.

Objective 2 – Explore and compare all the existing models that claim to measure project success to determine the best approach moving forward:

The literature review shows that almost all the popular project success models developed over the last 30 years are built upon Martin Barnes' Iron Triangle (on schedule, within budget, as specified), which has been generally rejected by academic researchers despite being broadly accepted by practitioners worldwide. It seems that every new idea just adds more CSFs that need to be considered, and the majority of them cannot be readily quantified. The 3D integration model is selected as the most appropriate because it relates directly to the core knowledge areas recognised by all project managers. This study has gone back to basics, but rather than a 2D triangle concept, the 3D integration model adds risk to form a pyramid. The new mantra for success is 'on schedule, within budget, as specified, no surprises'. For students studying project management with Bond University, at least, this is affectionately known as the 'Iron Pyramid'.

Objective 3 – Describe a generic framework for measuring PDS for application in the broader *i3d3* model based on Objective 2:

The simpler use of four CSFs has appeal, but it is reinforced with six KPIs that consider value, efficiency, speed, innovation, complication and impact – all measurable by formula using different combinations of the four CSFs. This study has added two new features to the previous model: namely the inclusion of TBL considerations represented by the faces of the pyramid, and the consideration of the difficulty of the project challenge as measured by the *Complexity Forecasting Cube*.

This approach does not preclude further CSFs being recognised. They could be separately monitored, albeit not formally part of PDS. For example, in the case of construction projects, worker safety is important. A proposed KPI might be life-threatening incidents (LTI), measured as a ratio to scope. The objective would be to minimise this KPI. Unlike the other KPIs mentioned above, LTIs cannot morally be traded against other KPIs, so it makes sense for it not to be part of the Iron Pyramid. That does not dilute its importance. Realistically, injuries or deaths on site lower perceptions of success, and hence just like complexity, could be a factor that smooths PDS to the downside when they occur.

The 3D integration model, focused on project management success, is now part of a broader model called *i3d3*, which focuses on project success.

Objective 4 – Test this framework's ability to evaluate relative performance for a collection of real case studies displaying different characteristics:

A dataset of 40 infrastructure projects of various types is the basis of the research findings. Six projects are excluded due to suspect performance data, such as might happen if projects increase in scope but have dramatic cost and time reductions – leading to unrealistic high PDS scores. Further investigations explain the actual reasons. Latent (unexpected) conditions discovered on site once work had commenced is the most common, resulting in significant changes to design and large contract variations. These projects appear as outliers when mapped on scatter plots. They represent 15% of the dataset. Given this was a small proportion; it still leaves 34 projects from which conclusions can be drawn.

It would have been preferable to have a larger dataset. In practice, this proved to be a difficult task due to the confidential and potentially damaging consequences should this information be made public. However, if such studies were conducted in-house, confidentiality is no longer a problem. This enables the model to have a good chance of industry adoption, just not with performance data stored centrally.

A key feature of the model is that it is agnostic to project type, size, location and date. The same cannot be said of most other reviewed models, many of which are quite specific to the construction industry.

Objective 5 – Validate the framework based on triangulation with other indicators of successful performance:

PDS scores are determined on the basis of the project data gathered, principally measurements of scope, cost, time and risk, each assessed at the start and finish of project delivery. Although the case studies possess different characteristics, the extended model was able to calculate an accurate PDS score for each of them. Projects are then ranked based on these scores. This highlights the model's ability to assess the performance of different projects in a way that comparisons among the projects can be made.

But is this ranking correct? In order to answer this question, PDS scores are correlated with PAR scores that reflect broader and more altruistic expectations of good practice. The adjusted R-square result was 53.6%, highlighting that higher success is aligned to higher project manager performance, which is generally supported by the literature. Triangulation was employed to confirm that the ranking made sense. The director of the collaborating organisation concluded it was. He instantly pointed to projects near the top of the list with a smile and said that these are projects that clients had expressed high satisfaction, and led to future work. He then pointed to projects near the bottom of the list, and remembered the reasons why they should be there. It appears that projects around PDS=0 do not seem out of place.

Objective 6 – Discuss the results of the research and report on ways in which PDS provides new insight and opportunities that can consistently realise better project outcomes:

Objectives 4, 5 and 6 collectively answer the study's research question: *does the ranking of projects according to PDS provide useful insight for project management consultancy practice in Australia to systematically improve its implementation performance?* The simple answer is YES.

Two examples of unexpected insight can be reported.

First, there should be no confidence in the link between success and organisational maturity. A positive correlation between PDS score and time is intuitively expected, indicating that success is more likely to occur when organisations are more mature. There is always an assumption that organisations get better over time through continuous improvement strategies, professional development and innovation. This is more likely for project-based organisations when a PMO is established that has independent oversight and responsibility for KPI outcomes. No formal maturity assessment had been performed on the collaborating organisation. Nor does it have a formal PMO. Nevertheless, its performance over time (according to PAR) slightly increased over a 10-year period. Success did not. This downward trend over time is shown earlier in Figure 44. This is despite a moderate correlation between PDS and PAR. A possible explanation is an increase in the number of concurrent projects and the lack of a formal culture of continuous improvement. The organisation's director acknowledges these deficiencies.

Second, it is discovered that value, speed and impact are KPIs that are likely to signal successful projects. Focus on these KPIs can lead to organisational benefits. The difference between these KPIs and efficiency, innovation and complication is their relationship with scope. Value is scope over cost (higher the better). Speed is scope over time (higher the better). Impact is risk over scope (lower the better). PDS is maximised when scope increases and cost, time and risk decrease. Seems obvious now, but it wasn't before.

6.4 IMPLICATIONS FOR PRACTICE

Projects are no longer seen as normal activities or as ordinary in a context of constant rivalry. Rather, projects are increasingly used as effective strategic tools to improve the productivity of companies, grow profit margins, operate in a volatile and increasingly competitive climate, become better corporate partners, and realise benefits for their consumers and stakeholders. The nature of project success management needs to shift from an operational/functional dimension to be more strategic. Considering that the criteria and priorities of each particular project are unique, success evaluation should be standardised (Ghanbaripour et al., 2017).

In order to assess project success and increase the performance and outcomes of all types of projects, a generic model is necessary. Enter *i3d3*. This research tested the 3D integration model and validated its capability to get the right answer. It is now built into *i3d3* as the method to measure the success of the project implement phase, and is freely available to all from the Centre for Comparative Construction Research (CCCR) at Bond University. But *i3d3* takes into account design (pre-implementation) and delight (post-implementation). It is recommended that project managers should have a matching broad remit to realise benefits for clients from project initiate to project influence. In other words, project managers should get involved early to ensure that clients 'do the right project' and stay connected until it can be ascertained that end-users confirm the project manager succeeded to 'do the right project right'.

While not part of the original plan, it became clear during the course of the research that PDS can be measured at interim stages of delivery. This realisation has potential to cause a fundamental shift from long-held engagement with earned value as a technique for holistically interpreting project performance. PDS can replace EVA and align decisions made during delivery with the evaluation of success upon completion. Such alignment can be integrated into a system of recording lessons learned in real time rather than when managers are getting ready to move on to their next project.

While the mechanisms and the equations in the model might appear complex, they actually are not. The six KPIs are generic and can be easily understood and applied in any project with minimal training. This makes the model remarkable since nearly every other success model requires data that practitioner do not have time to search for. Chapter 5 shows what steps could have been taken to get a failing project back on track using these KPIs. Different scenarios could be followed because each project is unique, and there is no standard response to fix unique problems. Understanding that success is a balance between scope, cost, time and risk baselines, there are an unlimited number of combinations that compute different PDS scores. Better performance is not the result of a reactive stance. Project managers should adopt a proactive stance and continually seek out better outcomes.

A Microsoft Excel® spreadsheet template is freely available for practitioners to use to measure success on their projects. This template is used to complete the two case studies included as part of Appendix 1. It can be downloaded from https://bond.edu.au/cccr.

6.5 FURTHER RESEARCH

There are two obvious areas of further research. The first is testing on real case studies comprising non-infrastructure project types, in order to demonstrate the generic capability of *i3d3*. The second is to explore the relationship between PDS and organisational maturity over time, exploring the hypothesis that the greater the organisation's maturity, the greater the likelihood of successful project outcomes. A method for measuring maturity for project management organisations has been developed and is available in Appendix 2.

6.6 CONCLUDING REMARKS

As few attempts have been made to create a generic model for measuring the success of project delivery, this study is a turning point in resolving the noise created from 22 different models over the last 30 years. The chosen way forward has enormous practical implications that should be underestimated. If used dynamically and consistently during project delivery, the model can help project managers to arrest more control and adopt performance enhancement as a continuous objective, empowering corrective action when necessary and ultimately ensuring stakeholder satisfaction is achieved. The extended Iron Pyramid, whether it stands alone as a means of assessing that projects are done right, or whether it fits within a broader context of financial, social, ethical and environmental responsibility across the entire project life cycle, makes a significant contribution to knowledge that resets the debate on what is success. Now we know.

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APPENDIX 1

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The following pages include the introduction to i3d3 and two case study examples.

The Application of the *i3d3* Model for Measuring Project Success

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6 December, 2019

Abstract

There is much confusion about what constitutes a successful project, or a quality outcome, since often the criteria applied are not made clear at the outset and the boundaries for what is to be included in the evaluation become blurred. To overcome this problem, a new approach called *i3d3* is presented for measuring project contributions based on the objectives of multiple stakeholder groups across the key life cycle phases of *initiate* (design), *implement* (deliver) and *influence* (delight). It also enables a method for benchmarking success regardless of type, size, location or date so that differential performance outcomes within a portfolio of projects or programs become manifest. It is concluded that there are generic and measurable criteria, or success factors, that are applicable for any project, whether this is an infrastructure, policy initiative, new product development, event, disaster recovery or other change intervention. A single score, on a scale of -100 to +100, can be computed to identify success and to compare projects regardless of context. This paper sets out the detailed procedure and calculation methodology behind the *i3d3* model for measuring project success.

Keywords: design decisions; project management; end-user satisfaction; benefit realization

1 Introduction

This paper unpacks the proposed methodology for *i3d3* – as originally developed by Langston, Ghanbaripour and Abu Arqoub (2018) – using a step-by-step procedure according to its three generic phases of *project initiate* (design), *project implement* (deliver) and *project influence* (delight). The *i3d3* model is agnostic to project type, size, location or date. It can be used to determine if a project is a success or a failure. It can also be used to rank projects in order of success. The resultant procedure is undertaken separately for each phase using different methods. Ultimate success is the arithmetic mean of success scores, equally weighted, across all three phases.

Figure 1 shows the conceptual framework (Langston, Ghanbaripour and Abu Arqoub, 2018) and details the structure of the model.

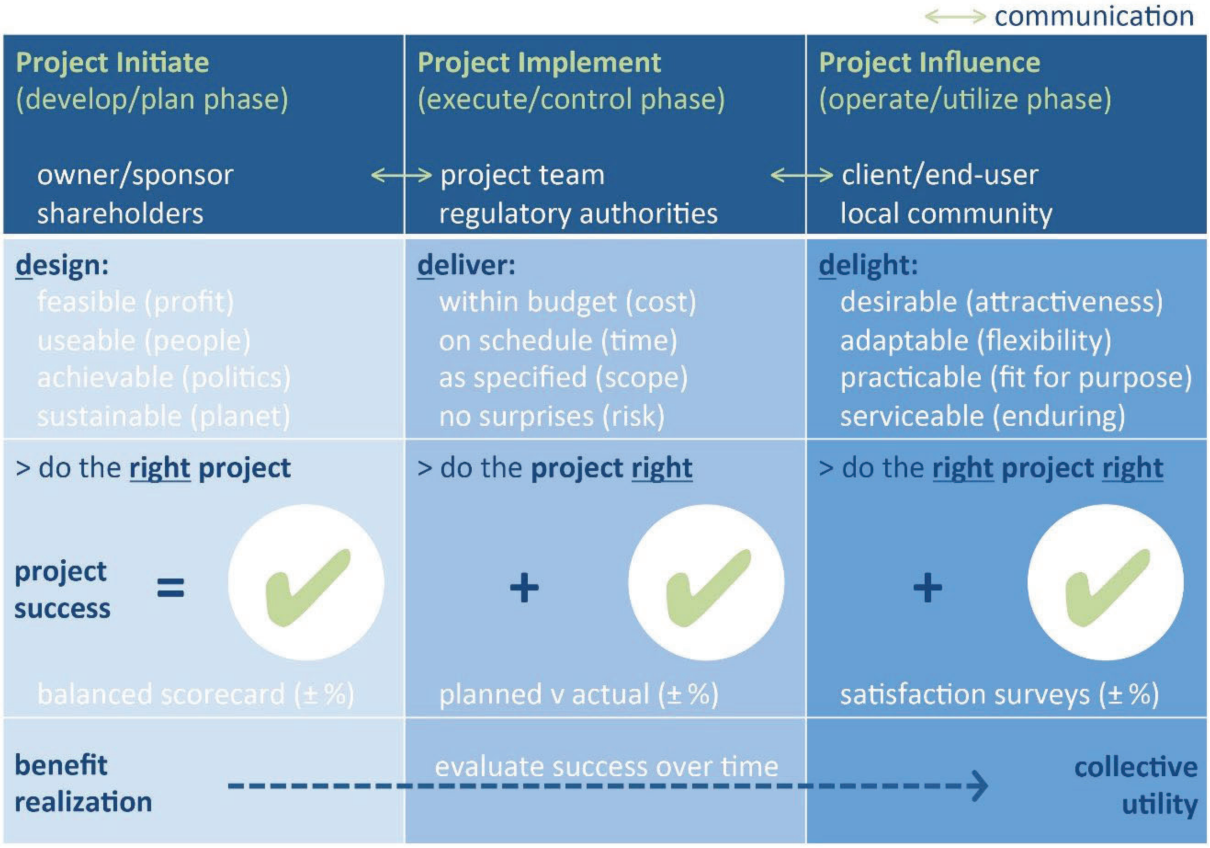

Figure 1: *i3d3* conceptual framework

Each phase of *i3d3* is explained in sequence.

2 Project Initiate Success

Success during this phase is judged from the perspective of the owner/sponsor of the project and shareholders. The focus is on selection of the project and includes success factors such as whether the project's design is feasible, useable, achievable and sustainable. These design success factors are collectively assessed in sequence and test whether the project itself reflects an appropriate course of action. A balanced scorecard approach is adopted to determine success.

Five steps are involved in assessing success within this phase.

Step 1: Being feasible is assessed from a profit-based perspective. The metric used to judge success is benefit-cost ratio (BCR), defined as the sum of the discounted benefits divided by the sum of the discounted costs over the life of the project. Benefits reflect forecast cash income, while costs reflect forecast cash expenditure. Cash flows may arise from capital, operating and financing commitments into the future. In *i3d3* it is important that they exclude intangible social, political and environmental factors that do not lend themselves to be discounted over time as is common in a traditional social cost-benefit analysis. In fact, in many cases these factors actually can become more significant, not less. Discount rate is applied to financial cash flows and is computed as the real weighted cost of capital (i.e. inflation-adjusted investment return). It has the effect of reducing the value of future benefits and costs as time passes up to a practical limit of 100 years. BCR is translated to a success score as shown in Figure 2.

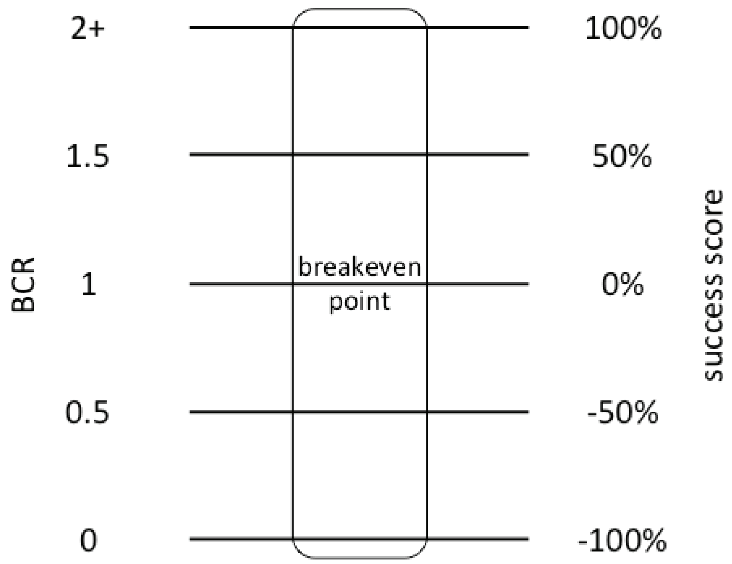

Figure 2: BCR success scale

Step 2: Being useable is assessed from a people-based perspective. The metric used to judge success is local project support (LPS), defined as the sum of opinion across a representative sample of the local community based on a clear and unbiased summary of the proposed project. A single statement seeks opinion on the level of support that exists in the community and computes LPS via a simple five-point Likert scale (see Table 1).

Table 1: LPS survey

Statement:	*strongly disagree*	*disagree*	*no opinion*	*agree*	*strongly agree*
I support this proposed project	-2	-1	0	1	2

A response rate within the sample of at least 30% (with a minimum of 30 responses) is targeted. Follow-up actions may be necessary if this is not initially achieved. In real time, this data would have been collected via the project sponsor's website using online polling. However, in this research, data must be collected retrospectively. The mean score of responses across the representative sample is then computed to arrive at LPS, which is translated to a success score as shown in Figure 3.

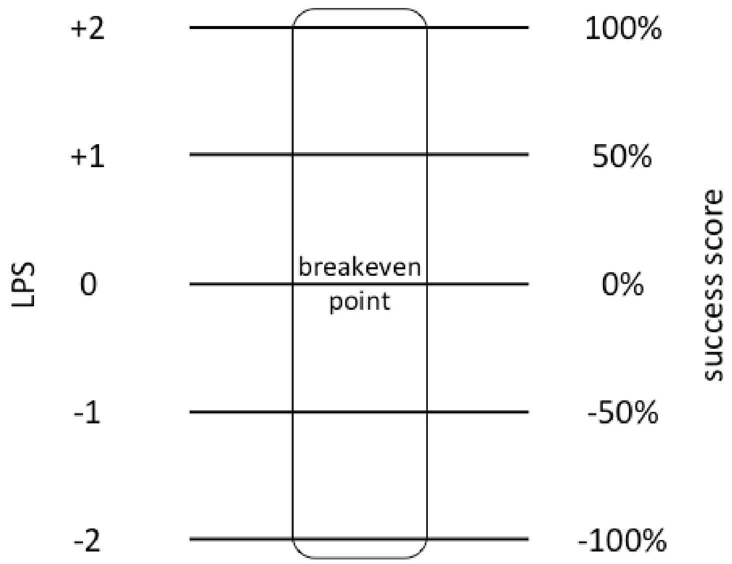

Figure 3: LPS success scale

Step 3: Being achievable is assessed from a politics-based perspective. The metric used to judge success is risk and reward (RAR), defined as the mean of the positive unknowns (opportunities) divided by the mean of the negative unknowns (threats) arising from the project's future governance over its life. Both probability and consequence are rated as 1 (low), 2 (moderate) or 3 (high) for each unknown and are multiplied together to compute individual risk and reward scores that lie between 1 and 9. At least five opportunities and five threats should be identified that impact on what might be called *cultural innovation* (or betterment). RAR is translated to a success score as shown in Figure 4.

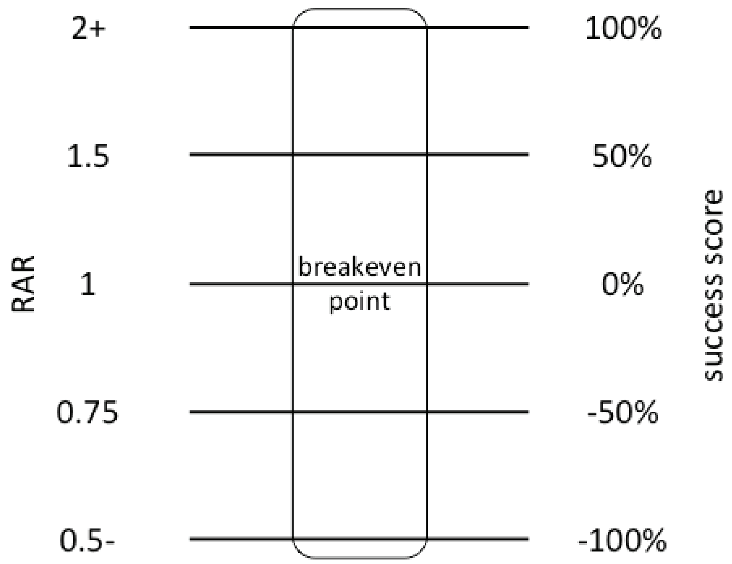

Figure 4: RAR success scale

Step 4: Being sustainable is assessed from a planet-based perspective. The metric used to judge success is ecological footprint (EFP), defined as the effect of upstream and downstream impacts resulting from the project over its life. These are computed using a scale comprising extreme (0 stars), high (1 star), moderate (2 stars), low (3 stars), minimal (4 stars) and regenerative (5 stars) across the categories of (i) non-renewable energy demand (embodied carbon), (ii) water quality impacts, (iii) air pollution, (iv) natural resource depletion, (v) biodiversity loss, and (vi) non-degradable or non-recyclable waste to landfill. EFP is informed by available environmental impact statements, life cycle analyses and other assessments, and translated to a success score as shown in Figure 5.

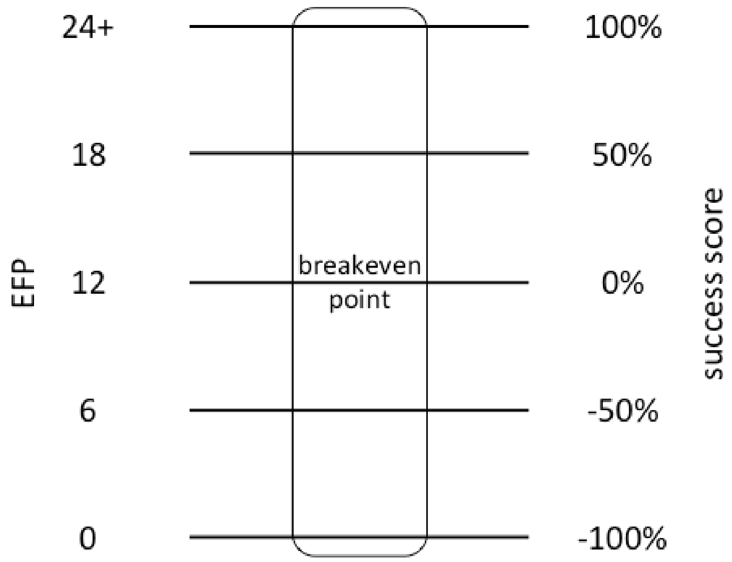

Figure 5: EFP success scale

Step 5: The overall success score for design is the outcome of a design support system (DSS) and is defined as the arithmetic mean ($\overline{x}$) of the success scores (S) for BCR, LPS, RAR and EFP that arise from the profit, people, politics and planet sub-systems respectively (see Equation 1). DSS values less than zero are considered unsatisfactory and normally would require changes to be made before proceeding further. In other words, design failure (i.e. DSS value < 0) should be avoided as it would be interpreted as unlikely to create an outcome that makes a progressive (i.e. positive) contribution to our world.

$$\text{DSS value} = \overline{x}\,(S_{BCR}, S_{LPS}, S_{RAR}, S_{EFP}) \qquad \text{(Eq.1)}$$

Figure 6, *adapted* from Beech (2013), highlights there is a sequence during the design process to ensure overall success can be achieved without exploring solutions that ultimately do not meet stakeholder expectations. Each success factor is treated like a compliance 'gate' before proceeding further, although ultimately there is a trade-off between factors to ensure that all meet minimum thresholds (e.g. financial return may be reduced to help mitigate anticipated environmental damage).

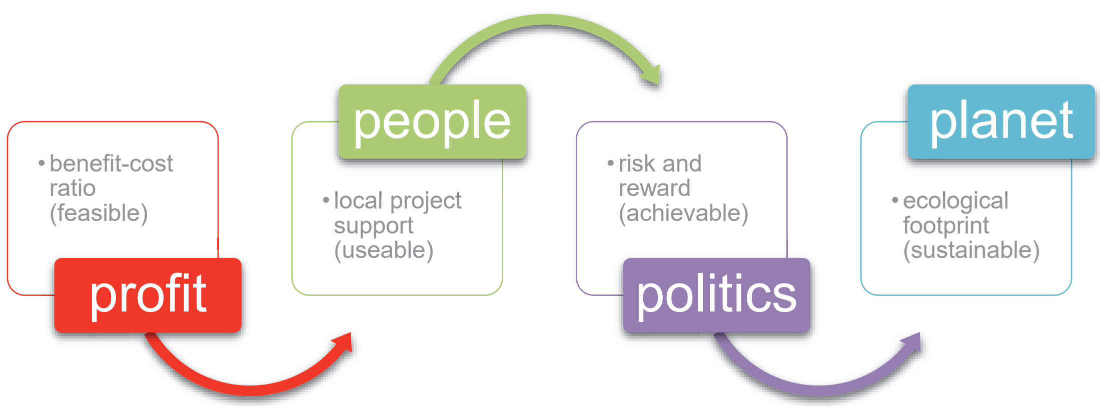

Figure 6: 4P design process

Figure 7, *adapted* from Langston (2018), illustrates the DSS logic that underpins good design in the context of project brief development. The key decision sequence of feasible, useable, achievable and sustainable is made clear, with progression occurring anticlockwise from the upper point of the diagram (denoted as *project brief*). An information database provides evidence for market, needs, policy and infrastructure analyses that lead to achievement of four important and generic milestones: business plan, project design, regulatory compliance and resourcing requirements (respectively). External input is required to assess income and expenditure, stakeholder satisfaction, cultural innovation, and environmental impacts. These are considered essential decision 'gates', regardless of project type, size, location or date, and directly influence corresponding measurable outcomes of BCR, LPS, RAR and EFP. Poor outcomes lead to reconsideration of fundamental decisions via feedback loops, which then impact on future project choices.

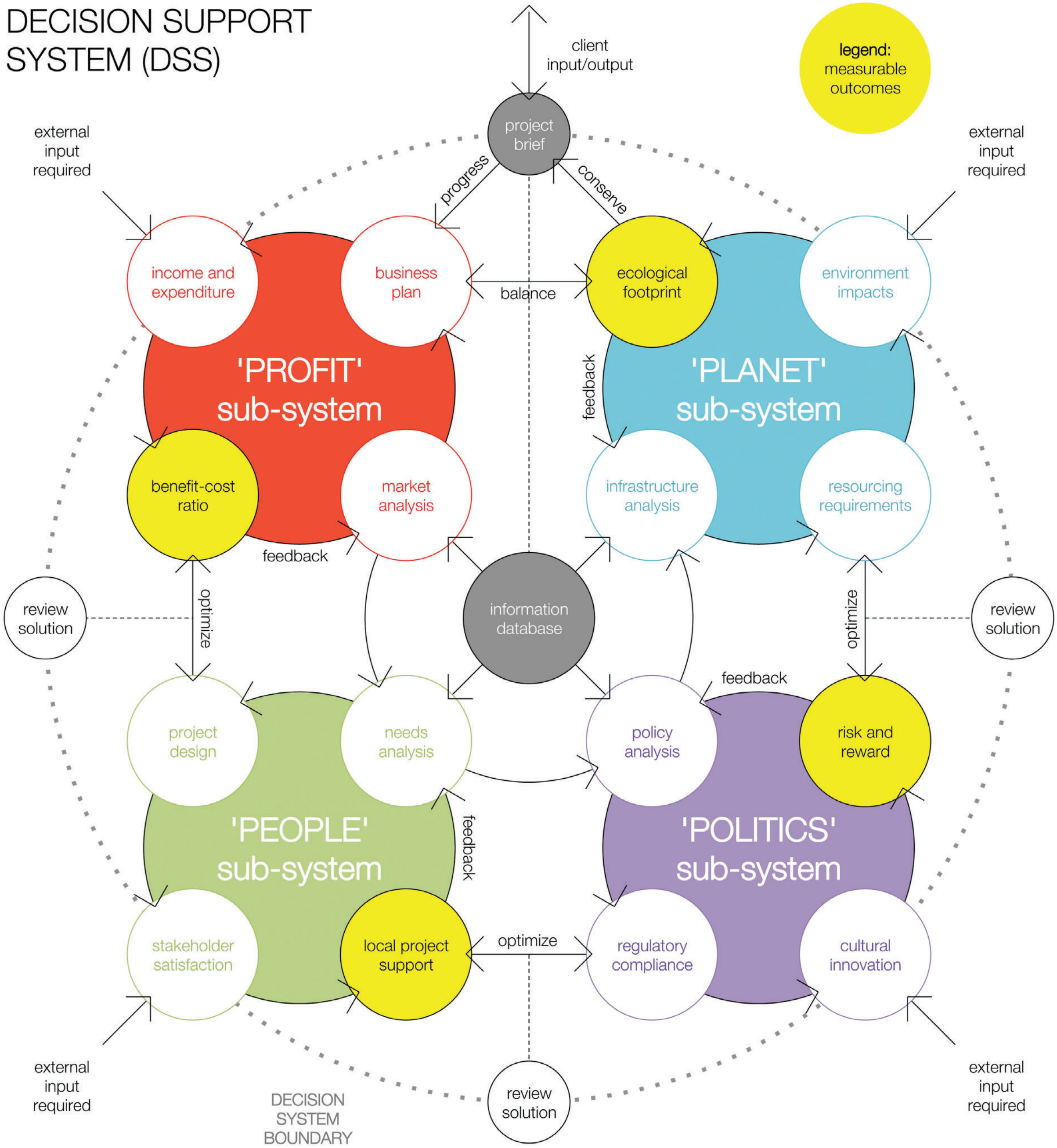

Figure 7: Decision-making processes

There is opportunity to review and optimize decisions throughout the DSS before fundamental design principles are settled and before detailed documentation and production can proceed. It is critical to treat the project brief as a 'conversation' with the design team to ensure that the best outcome is reached and owner/sponsor and shareholders are all fully on-board.

Design typically is a compromise between the often-opposing actions of 'progress' and 'conserve'. A balance needs to be struck. By treating the four sub-systems of design as having equal weight, decisions taken during this phase are forced to recognize and address any shortcomings rather than overlook or devalue them. It is suggested (although not mandatory) that, at least for the four design success factors, projects should surpass minimum standards of performance, and these standards have been identified in the previous discussions by the term breakeven point.

3 Project Implement Success

Success during this phase is judged from the perspective of the project team and regulatory authorities. The focus is on materialization of the project and includes success factors such as whether the project is delivered within budget (cost), on schedule (time), as specified (scope) and with no surprises (risk). The deliver success factors are assessed holistically and test whether the project itself achieves the agreed expectations upon handover, or indeed prior to handover using interim milestones to check progress in conjunction with or in lieu of conventional earned value reporting.

Communication between project initiate and project implement phases is critical to ensure that design and materialization are aligned. This helps ensure that projects are completed in a cooperative spirit with an understanding of sponsor goals and avoiding delivery conflicts.

The equation for determining the best mix of success factor performance is given by Equation 2 (Langston, 2013). Project delivery success (PDS) is calculated for both planned and actual performance, and the percentage change between them is computed. High positive changes between planned and actual PDS are preferred and indicate that delivery expectations were exceeded. A successful project should avoid a negative overall PDS score.

$$\text{PDS} = \frac{\text{scope}^3}{\text{cost . time . risk}} \qquad \text{(Eq.2)}$$

where:

cost = *the cost of implementing the project*
time = *the duration of the project from start to finish*
scope = *a measure of the size or extent of the project*
risk = *the √mean risk level (probability x consequence) of all risk events*

Six steps are involved in assessing success within this phase.

Step 1: Cost is defined as the price of the project, and both planned cost and actual cost are needed to compute the success score. Cost should include all cash outflows related to the project, such as consultant fees, taxes, fees, approvals, commissioning and testing, and defect rectification. Costs may be expressed in local currency or in a foreign currency, although in the latter case, the same exchange rate must be used for both planned and actual expenditure. Costs are not discounted to take account of the time value of money.

Step 2: Time is defined as the duration of the project, and both planned time and actual time are needed to compute the success score. It can be measured in hours, days, weeks or months from commencement to completion with no deductions for non-working periods, holidays, weekends or delays. External disruption to production schedules must not be eliminated from the calculation.

Step 3: Scope is defined as the size of the project, and both planned scope and actual scope are needed to compute the success score. An appropriate measure of scope needs to be selected that reflects corresponding changes in cost, time and/or risk should it be varied. In order words, the unit of scope must adequately describe the extent of works in a single metric (e.g. number, length, area, volume, functional unit, etc.). Scope changes during implementation must be approved.

Step 4: Risk is defined as the level of uncertainty of the project, and both planned risk and actual risk are needed to compute the success score. Risk, whether positive or negative, is the result of the probability (or likelihood) of an event and the consequences (or impact) that might result if it were to happen. Reduced risk is permissible if mitigation strategies are planned and included in scope, cost and time forecasts. A 3x3 matrix is recommended to compute risk where probability (1-3) and consequences (1-3) are multiplied together to realize a result between 1 (minimal) and 9 (extreme). Overall risk level is defined as the square root of the arithmetic mean of individual risk events regardless of whether they have a positive or negative influence. The probability for all actual risks is notionally set to 3 but their consequences may be lower than planned if they did not eventuate. Unanticipated risk events are added to the actual risk calculation only.

Step 5: The overall score reflects the percentage change between planned expectations and actual performance. PDS is effectively the success score as shown in Figure 8. It is capped within the range -100 to +100.

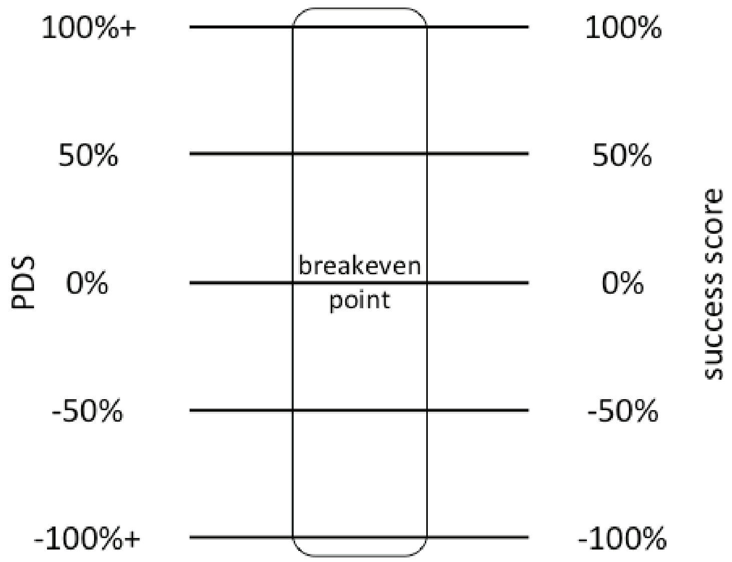

Figure 8: PDS success scale

However, the contribution that each of the four success factors has on the PDS is determined retrospectively using an algorithm that distributes the impact that each factor has on the PDS (see hypothetical example in Table 2).

Table 2: Scaling of PDS success factors

	planned	actual	impact	% change	scaled change
cost	25,000,000	26,500,000	245.10	-5.66%	-5.39%
time	250	240	270.63	4.17%	3.97%
scope	15,000	16,000	315.31	21.36%	20.33%
risk	2.08	2.11	255.98	-1.47%	-1.40%
				18.40%	17.51%
PDS	259.81	305.30		17.51%	-100≤PDS≤100

The measurement of PDS is based on the *PMBOK Guide®* (PMI, 2017). The link between *PMBOK®* knowledge areas and derived generic key performance indicators (value, efficiency, speed, innovation, complication and impact) is illustrated in Figure 9. The underpinning model for PDS takes the form of a tetrahedron, where the vertices, edges and faces all have assigned meaning (Ghanbaripour, Langston and Yousefi, 2017; Langston, Ghanbaripour and Abu Arqoub, 2018).

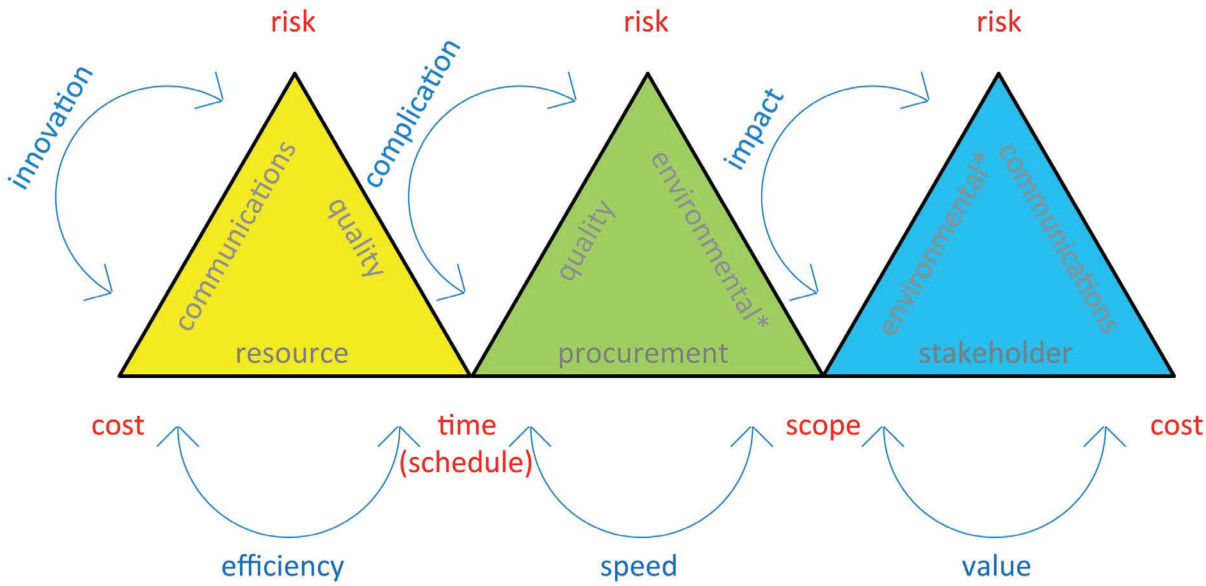

Figure 9: 3D integration model

Step 6: Project complexity is concerned with the magnitude of the challenge ahead. It is not an output but rather an input to the management of the change process of delivery. Complexity is considered to be a continuum from simple to chaotic. This continuum implies increased challenge from what is commonly called ‘known knowns’, to ‘known unknowns’ and ‘unknown unknowns’, and can even include the concept of ‘wicked’ problems that challenge effective resolution at all. Complexity is a variable in assessing project delivery success.

To assess the likely position of a new project on the complexity continuum, a means of scoring key project variables must be established. The *Complexity Forecasting Cube* (CFC) is a novel tool applied at the previous project initiate phase to determine complexity potential, represented by a number between 1 and 27 inclusive (Langston and Dhaduk, 2019). It takes the form of a 3D matrix that reflects simple (low score) to chaotic (high score) projects based on three coordinates:

- *X coordinate:* the scale of the challenge (low = local, moderate = regional/national, high = international)
- *Y coordinate:* the extent of uncertainty (low = mostly known knowns, moderate = many known unknowns, high = many unknown unknowns)
- *Z coordinate:* the diversity of stakeholders (low = single client, contractor and/or market, moderate = multiple clients, contractors and/or markets, high = broad community of project stakeholders displaying a wide range of interests and power)

Figure 10 summarizes the CFC, which is akin to a Rubik's cube (3x3x3 matrix). Each row of the cube is illustrated separately for greater clarity. The forecasted complexity potential score, which is computed as the multiplication of all three coordinates, signifies if a project is likely to be seen as simple (1-2), low complexity (3-4), complex (5-8), high complexity (9-15) or chaotic (16-27). Darker colours indicate higher complexity potential.

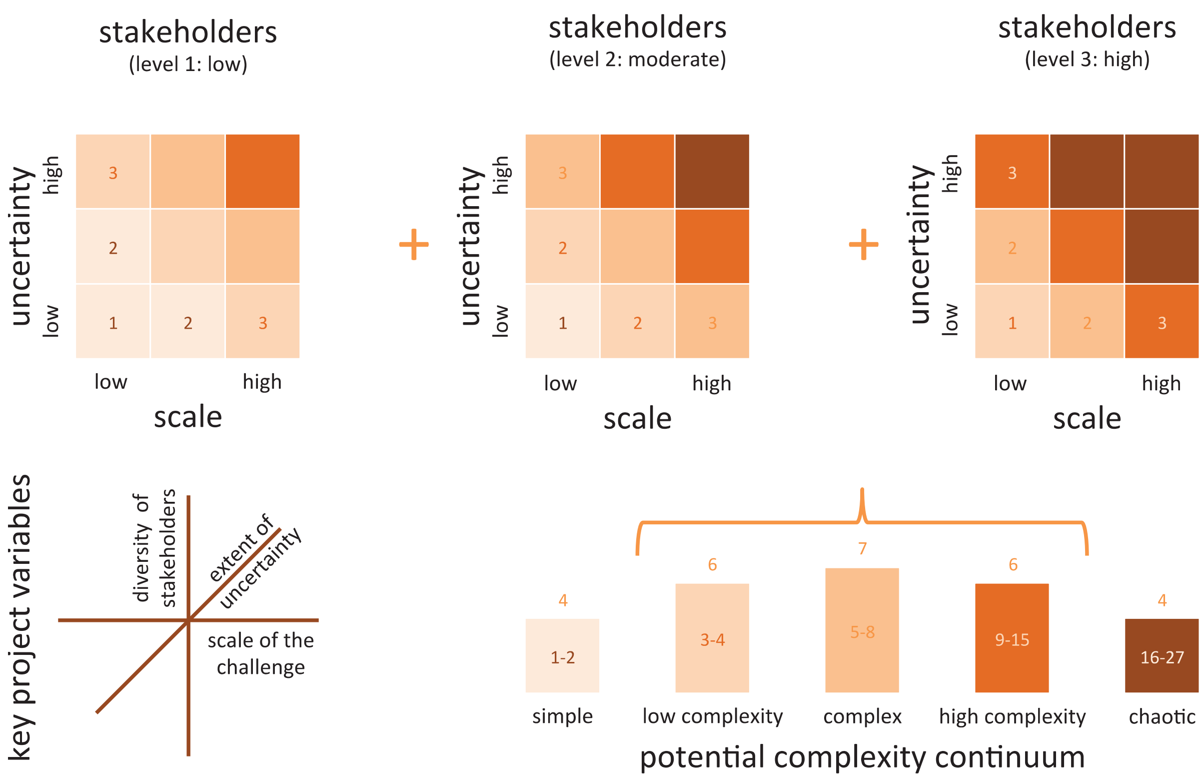

Figure 10: Complexity forecasting cube

The complexity score is deployed to adjust for the difficulty of the project challenge, and is akin to high platform diving in that the level of difficulty of the dive chosen factors into a diver's final score. Where chaotic or high complexity potential is expected, any negative success factor is adjusted to 50% or 75% of its normal value (respectively). Where simple or low complexity potential is expected, any positive success factor is adjusted to 50% or 75% of its normal value (respectively).

4 Project Influence Success

Success during this phase is judged from the perspective of the client/end-user of the project and the local community. The focus is on operational performance of the project and includes success factors such as whether the project is seen as desirable (attractiveness), adaptable (flexibility), practicable (fit for purpose) and serviceable (enduring). These delight success factors are assessed individually using a representative sample of stakeholders and a standard online questionnaire, and collectively tests whether the project itself is appreciated by those it was intended to serve.

Each success factor is assessed according to a list of ten generic project outcomes, plus up to two respondent-definable outcomes that give respondents a chance to include other issues that they think are significant to them. For each outcome, respondents provide their personal opinion (Question A) and personal relevance (Question B) using a five-point Likert scale, as shown in Tables 3 and 4.

Table 3: Project outcome opinion

Question A:	*strongly disagree*	*disagree*	*no opinion*	*agree*	*strongly agree*
Opinion of project outcome	-2	-1	0	1	2

Table 4: Project outcome relevance

Question B:	*not important*	*slightly unimportant*	*neutral*	*slightly important*	*very important*
Relevance of project outcome	1	2	3	4	5

A response rate within the sample of at least 30% (with a minimum of 30 responses) is targeted. Follow-up actions may be necessary if this is not initially achieved. The feedback ought to be collected after sufficient time has elapsed to make an informed comment, enabling users to gain familiarity with the project, explore its full functionality and overcome the initial fears or possible resistance to change. Time is also of importance because it allows any delivery frustrations to dissipate. Personal opinion (-2 to +2) and relevance (1 to 5) scores are multiplied together to arrive at weighted values that lie between -10 and +10. The arithmetic mean across all outcomes is then computed.

Five steps are involved in assessing success within this phase.

Step 1: Desirable relates to the attractiveness of the project and speaks of intrinsic value to the client/end-user or local community. It may include beauty, elegance, quality, empowerment and other intangible attributes that bring delight and happiness, or enable transformation. Considering the project holistically, each respondent is asked to assess Question A and Question B for the project outcomes listed in Table 5.

Table 5: Project outcomes (desirable success factor)

Nice to look at?
High quality?
Profitable?
Well-designed?
Valuable?
Prestigious?
Durable?
Popular?
Joyful?
Unique?
User-defined: ____________________?
User-defined: ____________________?

Step 2: Adaptable relates to the flexibility of the project and its ability to accept change without causing too much unnecessary disruption or churn. It may include future modifications or change of purpose, process re-engineering and avoidance of becoming prematurely obsolete. Considering the project holistically, each respondent is asked to assess Question A and Question B for the project outcomes listed in Table 6.

Table 6: Project outcomes (adaptable success factor)

Versatile?
Easily modified?
Able to be customized?
Multi-use?
Transportable?
Better with age?
Modular?
Scalable?
Technically clever?
Timeless?
User-defined: ____________________?
User-defined: ____________________?

Step 3: Practicable relates to the project being fit for purpose and fulfilling the specified requirements of the client/end-user or local community in terms of functionality and utility. Does it work well? Does it deliver on what was originally specified or needed? Considering the project holistically, each respondent is asked to assess Question A and Question B for the project outcomes listed in Table 7.

Table 7: Project outcomes (practicable success factor)

Functional?
Appropriate?
Robust?
Safe?
Healthy?
Problem-solving?
Easy to use?
Affordable?
Comfortable?
Ethical?
User-defined: ____________________?
User-defined: ____________________?

Step 4: Serviceable relates to the enduring nature of the project. Is it a project that will be treasured in future years and capable of upgrade as and when required? It may include sustainability, operational energy profile, future-proofing, premature obsolescence, and ongoing contributions to those it aims to serve. Is it in harmony with its natural surroundings? Considering the project holistically, each respondent is asked to assess Question A and Question B for the project outcomes listed in Table 8.

Table 8: Project outcomes (serviceable success factor)

Low maintenance?
Easily cleaned?
Recyclable?
Non-toxic?
Repairable?
Energy efficient?
Reliable?
Accessible?
Regenerative?
Habitat-safe?
User-defined: ___________________?
User-defined: ___________________?

Step 5: Two pairs of success factors will be constructed. These comprise 'wants' (the arithmetic mean of desirable and adaptable scores) and 'needs' (the arithmetic mean of practicable and serviceable scores). These values (for each respondent) are graphed on an X-Y scatter diagram. Satisfaction (or end-user happiness) is computed as the percentage of data points that lie in the upper right-hand quadrant (Q1) compared to the total number of data points across all quadrants. A hypothetical example is shown in Figure 11 (Q1 = 56.83%).

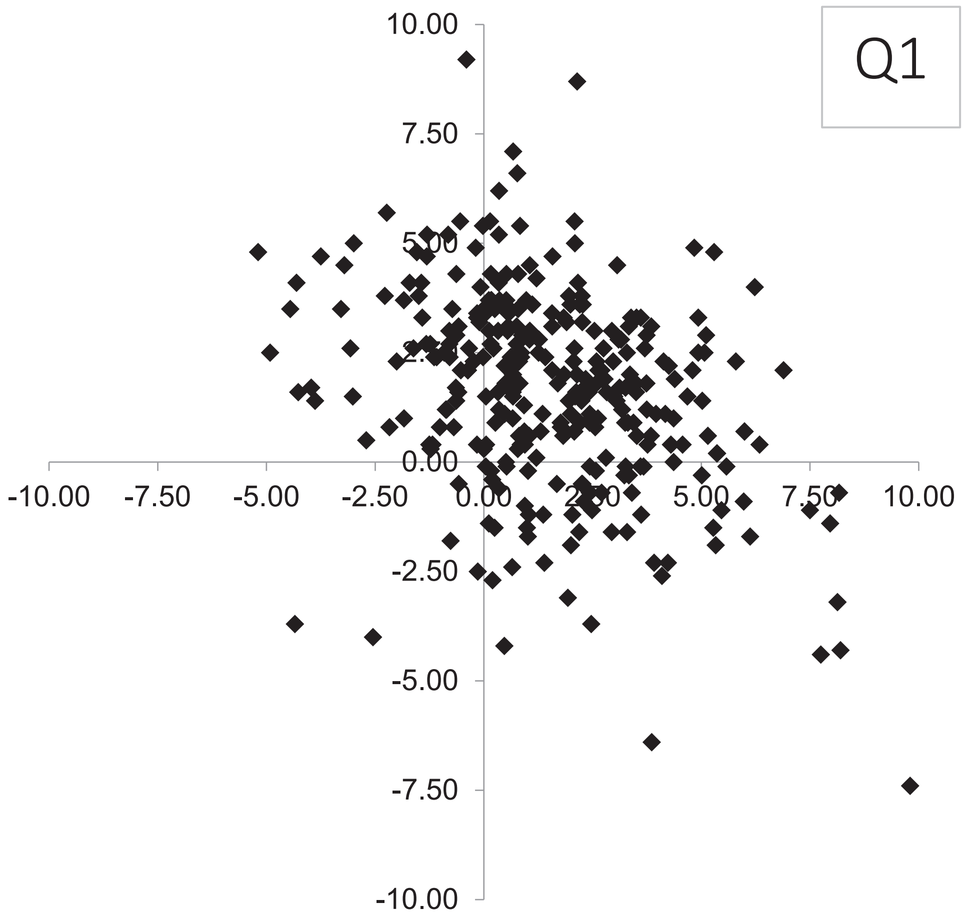

Figure 11: End-user happiness

End-user satisfaction (EUS) is equal to Q1. It can be compared with LPS multiplied by 50 to determine the extent of alignment between pre-delivery (design) expectation and post-delivery (delight) satisfaction. It is translated to a success score as shown in Figure 12. A successful project should have a value of at least 50% for EUS.

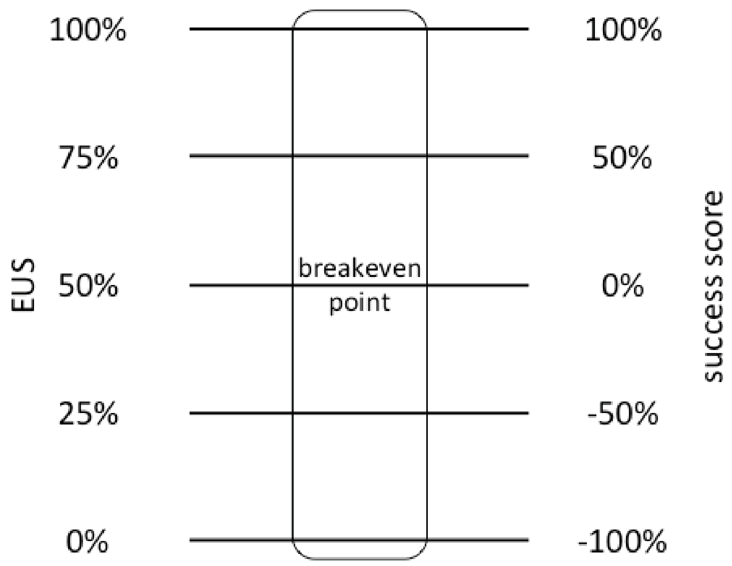

Figure 12: EUS success scale

The influence that each success factor has on the overall score can be computed via Equation 3, where *i* equals the number of responses per success factor and *n* equals the total number of responses across all success factors. These values are then used to proportion EUS across the success scores for each factor.

$$\text{Influence} = Q1 \cdot \frac{\bar{x}(A \cdot B)_i}{\bar{x}(A \cdot B)_n} \qquad \text{(Eq.3)}$$

Meaningful communication between the phases of project initiate and influence is critical to ensure that end-users are properly consulted. The role of the project manager is considered central in facilitating this dialogue. The concepts of *long life* (feasible and desirable), *loose fit* (useable and adaptable), *least pain* (achievable and practicable) and *low energy* (sustainable and serviceable) can serve as a language that aids communication between project designers and end-users. They help to align the intentions of the designer with the actual needs and wants of the end-user.

Figure 13, *adapted* from Abu Arqoub, Langston and Skulmoski (2018), indicates the mechanics of how end-user opinion can provide a positive reinforcing feedback (virtuous) loop for project designers, while also enhancing a project's success. There are four virtuous loops in *i3d3*. For example, a feasible project developed during design is expected to be more desirable by end-users, which would encourage them to have longer engagement with the project and mitigating premature obsolescence. A long life makes the project even more feasible. The same thinking applies to help make projects more useable, more achievable and more sustainable, and therefore supports continuous improvement.

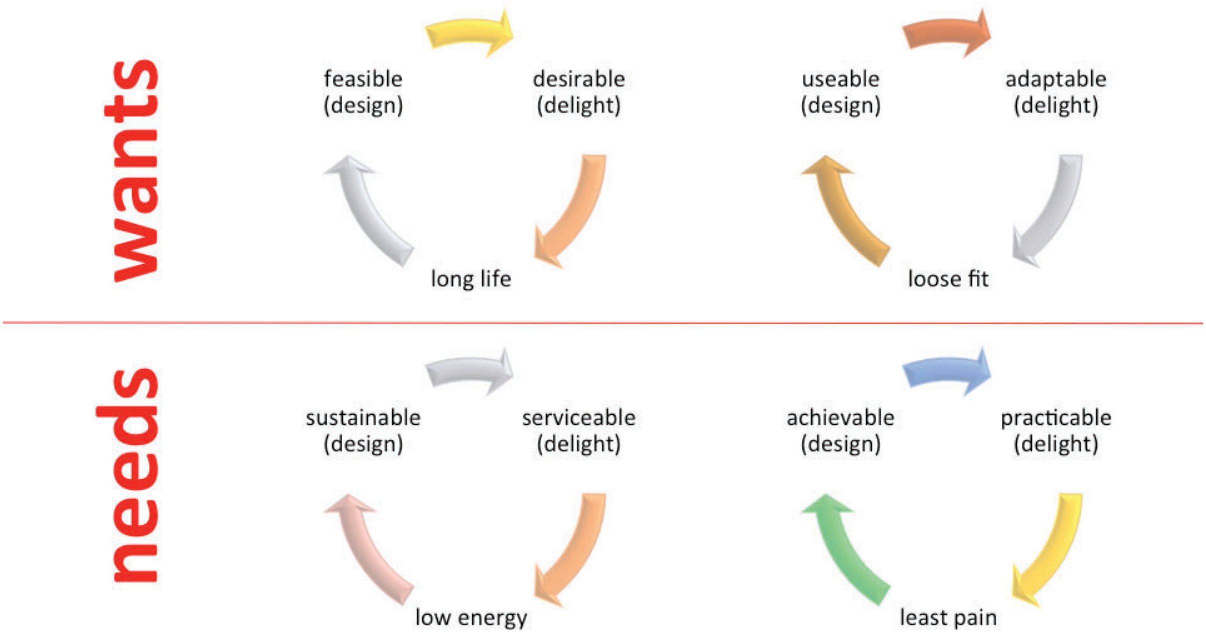

Figure 13: Virtuous loops

5 Benefit Realization

Benefit(s) realization is about ensuring project objectives are fulfilled. This may take many years to eventuate. Hence, success is an on-going activity with perceptions concerning end-user delight changing over elapsed project life. This research allows up to one year from project completion to assess the four delight success factors, and it is acknowledged that this gives only a small insight into the operational satisfaction of large projects that may have very long and dynamic operating lives.

Success is a function of stakeholder satisfaction and is reflected in the relationships that are formed and maintained between key people over time. With that comes the realization that there is more than one stakeholder to please, that project objectives will vary between them, and that the passage of time is an important ingredient in understanding and quantifying satisfaction. Judging criteria should be transparent. But none of this precludes generic criteria independent of project type, size, location or date.

There is horizontal connectivity between success factors (e.g. feasible, within budget, desirable) that ties back to the wider system characteristics of financial (long life), social (loose fit), ethical (least pain) and environmental (low energy) consequences. Benefits can arise from any of these consequences.

Ultimate success is computed as the arithmetic mean of design, deliver and delight success scores, each judged in the context of a different stakeholder group. The stakeholder group for project initiate phase is comprised of owner/sponsor and shareholders; project influence is project team and regulatory authorities; and project influence is client/end-user and local community. High scores are preferred.

Table 9 demonstrates how this might be converted into a single rank index (scores provided here are for illustrative purposes only).

Table 9: Overall success scores

Consequences	*Project Initiate*	*Project Implement*	*Project Influence*	*Score (%)*
Financial (long life)	feasible	within budget	desirable	78
Social (loose fit)	useable	on schedule	adaptable	69
Ethical (least pain)	achievable	as specified	practicable	71
Environmental (low energy)	sustainable	no surprises	serviceable	62
Score (%)	80	58	72	**70**

The four consequences (financial, social, ethical and environmental) can be mapped against the seventeen Sustainable Development Goals published by the United Nations (see Figure 14). Financial consequences relate to *Goal 8* (Decent Work and Economic Growth), *Goal 9* (Industry, Innovation and Infrastructure), *Goal 11* (Sustainable Cities and Communities) and *Goal 12* (Responsible Consumption and Production). Social consequences relate to *Goal 1* (No Poverty), *Goal 2* (Zero Hunger), *Goal 3* (Good Health and Well-being) and *Goal 4* (Quality Education). Ethical consequences relate to *Goal 5* (Gender Equality), *Goal 10* (Reduced Inequalities), *Goal 13* (Climate Action) and *Goal 16* (Peace, Justice and Strong Institutions). Environmental consequences relate to *Goal 6* (Clean Water and Sanitation), *Goal 7* (Affordable and Clean Energy), *Goal 14* (Life below Water), *Goal 15* (Life on Land) and *Goal 17* (Partnerships for the Goals).

Figure 14: Sustainable Development Goals (https://www.un.org/sustainabledevelopment/sustainable-development-goals/)

It is useful for project success to be viewed through the lens of global humanitarian contributions, where appropriate. In *i3d3*, *Goals 1-16* have the potential to be realized when the relevant consequence score is 50 or more, as shown in the final column of Table 9. Only the primary goal under each consequence is eligible to be selected. For *Goal 17* to be relevant, the delivery complexity score needs to be 12 or more, indicating significance in the scale of the challenge, the extent of uncertainty and/or the diversity of stakeholders. A 'humanity index' out of 100 can be computed. Benefit justification needs to be recorded to complete the mapping exercise.

Stakeholder benefits relate closely to project success. The net benefit for a project should include the humanity index, but should also take account of whether individual benefits are actually realized. However, not all stakeholders receive equal reward – there will potentially be both winners and losers – so it is necessary to map identified benefits against individual stakeholders. Benefits can be tangible or intangible, direct or indirect, planned or emergent, and short, medium or long term (PMI, 2019). Of interest here is the comparable level of benefits between stakeholders, and whether these benefits are positive or negative. Some stakeholders may possess different levels of power (or influence) and interest (or involvement) that can affect their relationship with the project over time, resulting in varied strategies for engagement. Stakeholders need to be managed closely (high power and interest), kept satisfied (high power and low interest), kept informed (low power and high interest) or monitored (low power and low interest).

Obviously, not all projects will be successful – for example, some may just be motivated by self-serving political imperatives or be poorly planned responses to an emergency situation – and fail to deliver the benefits or collective utility demanded of them, let alone the global humanitarian contributions they make. Being able to rank projects in hindsight according to their level of success, however, is still valuable. It enables both reflection and continuous improvement to occur, ensuring we have an opportunity to learn from things that worked and from things that didn't. That is what continuous improvement is really all about.

6 Conclusion

The *i3d3* approach is expected to apply to projects of any type, size, location or date. Criteria are generic. Size may affect the quantum of benefits realized but not the requirement to secure benefits and positive collective utility. The approach is also applicable to any country, whether rich or poor, and hence can support international comparisons.

The novelty of *i3d3* lies in its comprehensive approach and integration of (a) design decisions that ensure projects are feasible, useable, achievable and sustainable with (b) the classic delivery expectations of being within budget, on schedule, as specified and with no surprises, as well as (c) providing client, end-user and/or local community satisfaction in terms of the balance between their wants (outcomes that are desirable and adaptable) and their needs (outcomes that are practicable and serviceable). Using the overall project success score obtained from *i3d3*, we should be able to compare levels of project success between different project-based endeavours of potentially any type. Whether comparing a doghouse with an opera house, or a new aircraft roll-out with a refurbished apartment building, or a telecommunications tower with relocating an organization to bigger premises across town, *i3d3* can rate the success of projects in both relative and absolute terms.

In essence, *i3d3* is a composite index consisting of indicators designed to measure success on the different factors that determine benefits to diverse groups of stakeholders. Projects that display financial (feasible, within budget and desirable), social (useable, on time and adaptable), ethical (achievable, as specified and practicable) and environmental (sustainable, no surprises and serviceable) benefits are more likely to provide positive collective utility to society as a whole. These indicators are called success factors and apply across project life cycle phases. We can only expect to do better if we are willing to learn from the lessons of the past. The rigour of the evaluation makes those lessons transparent and supports the principle of continuous process improvement.

The *i3d3* calculation template for use in measuring and ranking project success is freely provided and can be downloaded from https://bond.edu.au/cccr. Two case studies of its application are also available upon request.

7 References

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i3d3 RANKING	51	Bangladesh Electricity Upgrade and Expansion (BEUE) Project

CONSEQUENCES	Project Initiate	Project Implement	Project Influence	Score (%)
Financial (long life)	100	18	88	**69**
Social (loose fit)	50	-75	89	**21**
Ethical (least pain)	83	0	88	**57**
Environmental (low energy)	92	-10	88	**57**
Score (%)	**81**	**-17**	**88**	**51**

The Government of Bangladesh has identified electricity supply as a major constraint on GDP growth and overall economic development. To address these challenges, it has adopted a multipronged plan involving substantial sector investments, regional power trade and sector reforms. The Government has an ambitious target to achieve affordable electricity for all by 2021. To realize this target, new generation capacity must be complemented by upgrading transmission and distribution networks, as well as establishing connections for new consumers. The Government requested the Asian Infrastructure Investment Bank provide financial support for the BEUE project. This funding will: (i) expand electricity coverage by providing 2.5 million new service connections in rural areas and (ii) upgrade two grid substations (250 MVA to 480 MVA) and convert overhead distribution lines into 85 km of underground cables in northern Dhaka. BEUE will supplement other development partner efforts by providing additional financial resources to connect more rural and urban consumers, further reduce distribution losses, and improve the quality and reliability of power supply in Bangladesh. Upon completion it is expected to benefit about 12.5 million people in rural areas. Some delays to the underground cabling were experienced due to inclement weather.

i3d3 ranking

Success is measured on a scale of -100 to +100, where the border of success and fail is set at zero. The above table shows success according to project phases and consequences. Each value in this table is assigned equal weight. Light red shaded cells are problems. Success can be a surrogate for wider project 'quality'.

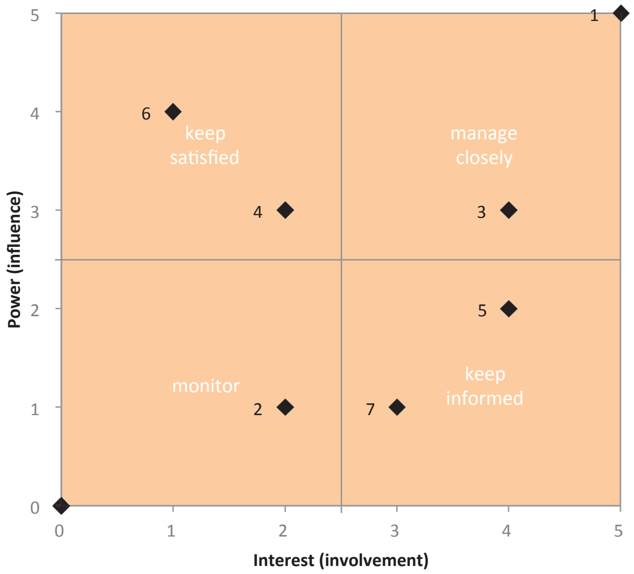
NET BENEFIT	68	Bangladesh Electricity Upgrade and Expansion (BEUE) Project

BENEFIT REALIZATION	winners	6	losers	1

Stakeholders:

	stakeholder ID#	power 1-5	interest 1-5	expected value (%)
Owner/sponsor	1	5.0	5.0	100
Local community	2	1.0	2.0	50
Shareholders/authorities	3	3.0	4.0	83
Environmentalists	4	3.0	2.0	92
Project team	5	2.0	4.0	-17
Client/end-user	6	4.0	1.0	88
Wider society	7	1.0	3.0	80
	8			
	9			
	10			
	11			
	12			

key: 1=minimal 2=low 3=moderate 4=high 5=extreme

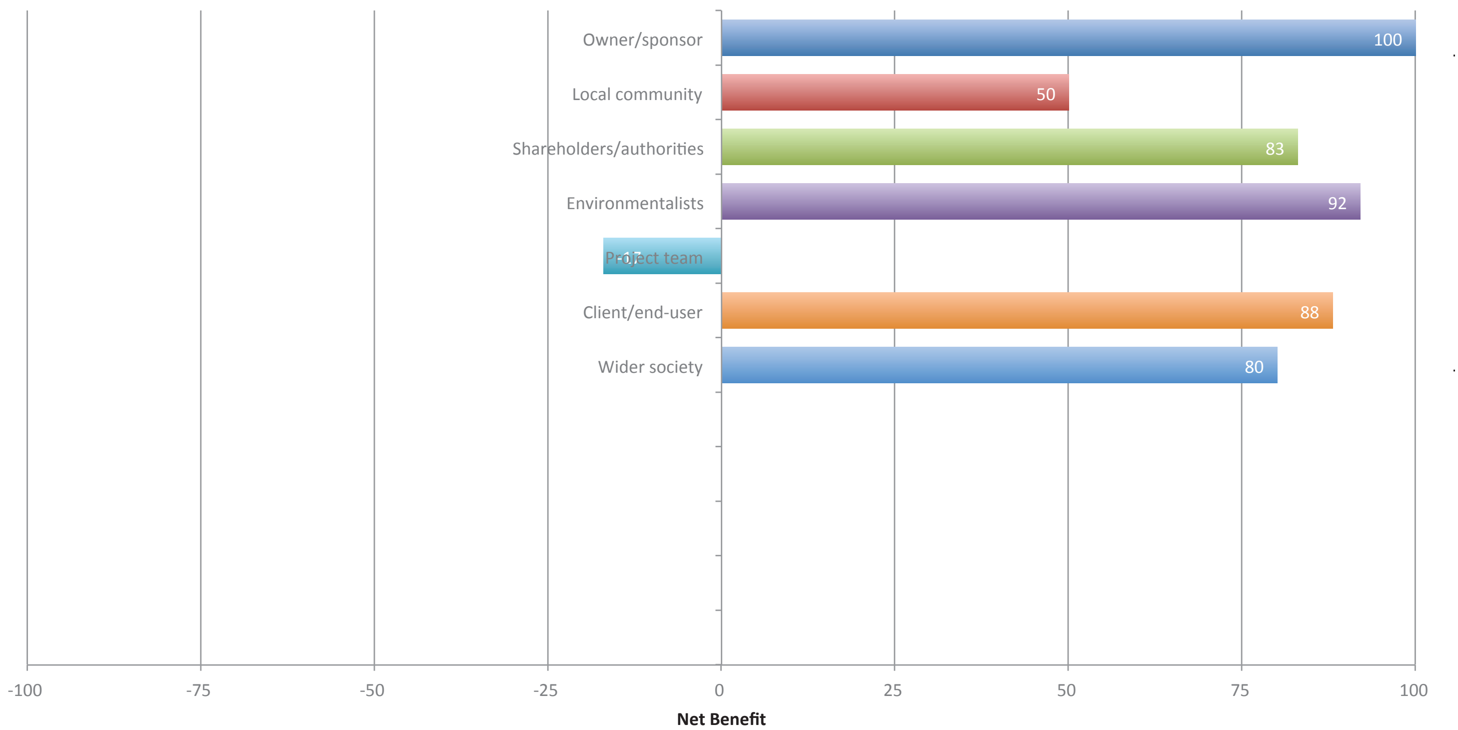


Benefit Register:

	benefit ID#	T/I	D/I	P/E	S/M/L	stakeholder ID#	expected value (%)	realized? Y/N	comments
BCR success score (design) > 0	1	T	D	P	M	1	100	Y	
LPS success score (design) > 0	2	I	I	P	S/M/L	2	50	Y	
RAR success score (design) > 0	3	T/I	D/I	P	M/L	3	83	Y	
EFP success score (design) > 0	4	I	I	E	L	4	92	Y	
PDS success score (deliver) > 0	5	T	D	P	S	5	-17	Y	Project delivery was considerably delayed
EUS success score (delight) > 0	6	T	D/I	P	S/M/L	6	88	Y	
SDG humanity index > 0	7	I	I	P/E	L	7	80	Y	
	8								
	9								
	10								
	11								
	12								

key: tangible / intangible; direct / indirect; planned / emergent; short term / medium term / long term

mean = 68%



UNITED NATIONS SUSTAINABLE DEVELOPMENT GOAL (SDG) CONTRIBUTIONS — benefit justification

Financial: 20

investments in infrastructure are crucial to achieving sustainable development

enter primary SDG# here > 9

BEUE is intended to provide reliable electricity provision to 2.5 million households in rural Bangladesh for the first time.

Social: 0

economic growth must be inclusive to provide sustainable jobs and promote quality

not eligible 1

The intention is to help lift 12.5 million people out of poverty by providing electrical power, however, the delay in delivering this project has minimized the potential benefit.

Ethical: 20

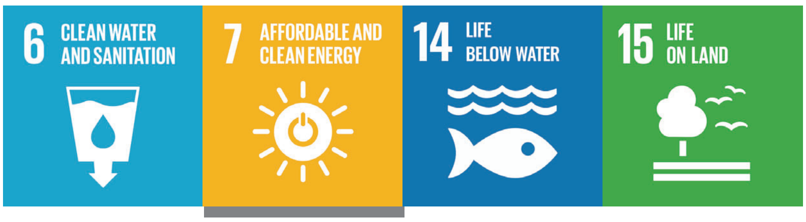
to reduce inequalities, policies should be universal in principle, paying attention to the needs of disadvantaged and marginalized populations

enter primary SDG# here > 10

Targeted existing households do not currently have access to electricity, and instead use fossil fuels for heating, cooking and other basic household needs.

Environmental: 40

energy is central to nearly every major challenge and opportunity



enter primary SDG# here > 7

While the provision of electrical power is not 100% clean, it is planned to build a new nuclear power plant to service the increased demand. Existing gas fired power plants are nevertheless cleaner than burning charcoal and wood.

revitalize the global partnership for sustainable development

enter SDG#17* here > 17

*this SDG is only available when the complexity score (delivery) is 12 or more

BEUE was a partnership between the Bangladesh government and the Asian Infrastructure Investment Bank to provide basic infrastructure to rural areas of the country and, in the process, reduce pollution caused by the burning of fossil fuels.

SUCCESS FACTOR

feasible	useable	achievable	sustainable
100	50	83	92

Profit:

Benefit-cost ratio (BCR) **2.0502**

year	benefit	discounted benefit	cost	discounted cost
0		-	23	23
1		-	6,272	6,149
2		-	7,997	7,686
3		-	6,272	5,910
4	5,335	4,929	267	246
5	5,335	4,832	267	242
6	5,335	4,737	267	237
7	5,335	4,644	267	232
8	5,335	4,553	267	228
9	5,335	4,464	267	223
10	5,335	4,377	267	219
11	5,335	4,291	267	215
12	5,335	4,207	267	210
13	5,335	4,124	267	206
14		-		-
15		-		-
16		-		-
17		-		-
18		-		-
19		-		-
20		-		-
21		-		-
22		-		-
23		-		-
24		-		-
25		-		-
26		-		-
27		-		-
28		-		-
29		-		-
30		-		-
		45,158		22,026

discount 2.00 %
currency BDT (million)

assume BCR (override)

Notes
Benefits and costs should exclude intangible cash flows
Discount rate is net of inflation (i.e. real discount rate)
Cash flows are expressed in Year 0 terms
BCR can be entered directly using 'assume BCR' cell
Original feasibility study not avaiable
Income = 2.5m households x 400KWh/year x BDT 5.335/KWh
Maintenance and repair costs assumed at 5% of income
Marginal cost of energy generation is excluded
Usage cost based on residential consumer
Average household size = 5 people
BCR = 2 threshold reached after 10 years of operation
New Russian-built Rooppur nuclear power plant online by 2024

People:

Local project support (LPS) **1.0000**

Statement: *I support this proposed project*

strongly disagree	disagree	no opinion	agree	strongly agree	responses
2	8	-	72	22	104

sample N/A
return rate 0%

Politics:

Risk and reward (RAR) **1.8286**

ID	reward (opportunities) - * must complete 5	probability 1-3	consequence 1-3	risk level 1-9
A*	Affordable electricity for all by 2021	1	3	3
B*	Replace more polluting current energy sources	3	3	9
C*	Improve essential infrastructure and grow GDP	3	2	6
D*	Increase the number of rural and urban consumers	3	1	3
E*	Make existing distribution networks more resilient	2	2	4
F	Reduce poverty	1	3	3
G	Minimize electricity distribution losses	2	2	4
			mean	4.57

ID	risk (threats) - * must complete 5	probability 1-3	consequence 1-3	risk level 1-9
A*	Undertake Environmental and Social Review (ESR)	3	1	3
B*	Undertake Initial Environmental Examination (IEE)	3	1	3
C*	Unable to obtain sufficient finance for construction	1	3	3
D*	Affordable consumer pricing	1	3	3
E*	Increased risks of blackouts due to greater demand	1	1	1
F	Disruption during construction	1	2	2
G				
			mean	2.50

Planet:

Ecological footprint (EFP) **22.0000**

environmental categories (impacts)	extreme (0 stars)	high (1 star)	moderate (2 stars)	low (3 stars)	minimal (4 stars)	regenerative (5 stars)
non-renewable energy demand (embodied carbon)			Y			
water quality impacts					Y	
air pollution					Y	
natural resource depletion					Y	
biodiversity loss					Y	
non-degradable or non-recyclable waste to landfill					Y	
	0	0	1	0	5	0

DELIVER (PDS)	-17	Bangladesh Electricity Upgrade and Expansion (BEUE) Project

SUCCESS FACTOR	within budget	18	on schedule	-75	as specified	0	no surprises	-10

Cost:

	planned	actual		change
Construction (BDT million)	20,563.54	19,669.78	✔	-4.35%

Time:

	planned	actual		change
Onsite activity (calendar month)	36.00	54.00		50.00%

Scope:

	planned	actual		change
New service connections (million)	2.50	2.50	✔	0.00%

Risk:

	planned	actual		change
√ mean risk level (1-3)	2.00	2.07		3.51%

KPIs

-100 ≤ PDS ≤ 100

		change
value (scope/cost)	✔	4.54%
efficiency (cost/time)		-36.23%
speed (scope/time)		-33.33%
innovation (risk/cost)	✔	8.21%
complication (time/risk)	✔	44.91%
impact (scope/risk)		-3.39%
profit ($scope^2/cost^2$)	✔	9.29%
people ($scope^2/time^2$)		-55.56%
planet ($scope^2/risk^2$)		-6.67%
progress (TBL mean)		-17.64%

COMPLEXITY

12

high

	1-3
X: scale	2
Y: uncertainty	2
Z: stakeholders	3

Planned risk events

Probability and consequence are assessed after any mitigation strategies have been included in scope, cost and time estimates

ID	risk event - * must complete 5	planned probability 1-3	planned consequence 1-3	planned risk level 1-9
A*	Delays due to cyclone flooding (May-November)	3	3	9
B*	Seismic activity causing damage to completed work	1	3	3
C*	Price increase for equipment resulting in project cost overruns	2	2	4
D*	Inadequate measures to mitigate local transportation disruption	2	2	4
E*	Procurement failure and/or improper tendering procedures	1	2	2
F	Inadequate record-keeping leading to potential corruption	1	3	3
G	Misuse of loan proceeds	1	3	3
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
			√ mean	2.00

Actual risk events

Consequence is determined based on final project outcomes, and should include any unanticipated risk events

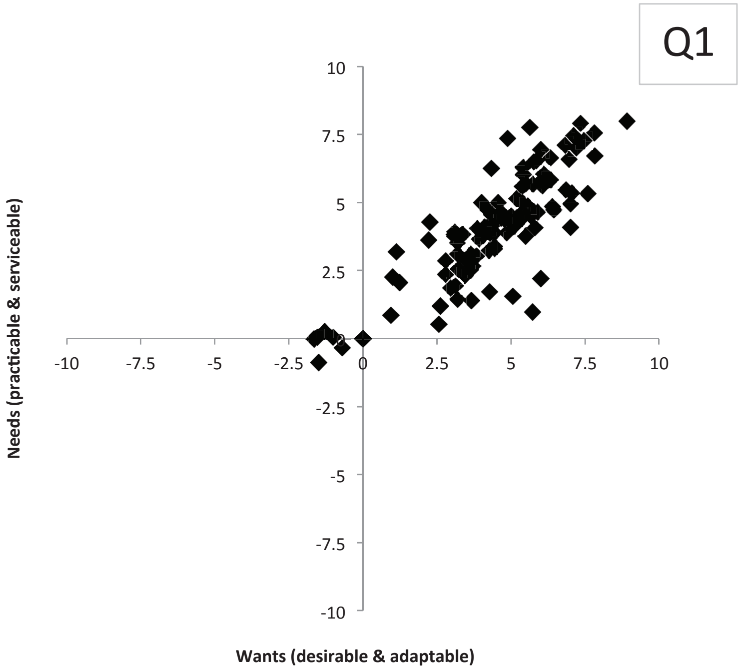
ID	risk event - * must complete 5	actual probability 1-3	actual consequence 1-3	actual risk level 1-9
A*	Delays due to cyclone flooding (May-November)	3	3	9
B*	Seismic activity causing damage to completed work	3	1	3
C*	Price increase for equipment resulting in project cost overruns	3	2	6
D*	Inadequate measures to mitigate local transportation disruption	3	1	3
E*	Procurement failure and/or improper tendering procedures	3	1	3
F	Inadequate record-keeping leading to potential corruption	3	1	3
G	Misuse of loan proceeds	3	1	3
H		-		
I		-		
J		-		
K		-		
L		-		
M		-		
N		-		
O		-		
P		-		
Q		-		
R		-		
S		-		
T		-		
			√ mean	2.07

DELIGHT (EUS)	88	Bangladesh Electricity Upgrade and Expansion (BEUE) Project

SUCCESS FACTOR	desirable	88	adaptable	89	practicable	88	serviceable	88

Attractiveness:

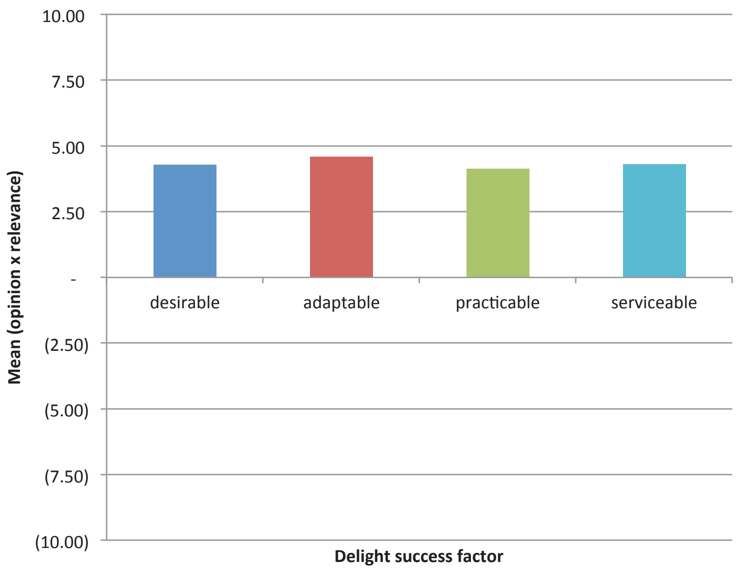
	mean	influence
Nice to look at?	3.75	
High quality?	5.46	
Profitable?	3.51	
Well-designed?	4.55	
Valuable?	3.67	
Prestigious?	4.60	
Durable?	5.15	
Popular?	4.61	
Joyful?	4.02	
Unique?	3.48	
User-defined ...		
User-defined ...		
	4.28	24.74%



percent Q1	94.23	%
total responses	104	

Flexibility:

	mean
Versatile?	5.45
Easily modified?	4.96
Able to be customized?	5.11
Multi-use?	2.11
Transportable?	4.68
Better with age?	5.14
Modular?	4.18
Scalable?	4.35
Technically clever?	5.49
Timeless?	4.35
User-defined ...	
User-defined ...	
	4.58	26.50%



Fit for Purpose:

	mean
Functional?	4.29
Appropriate?	4.21
Robust?	3.67
Safe?	6.50
Healthy?	5.09
Problem-solving?	4.00
Easy to use?	4.90
Affordable?	1.95
Comfortable?	3.58
Ethical?	3.12
User-defined ...	
User-defined ...	
	4.13	23.89%

sample		N/A
return rate		0%
expected delight (LPS)		50%
actual delight (EUS)	✔	88%

Enduring:

	mean	
Low maintenance?	0.44	
Easily cleaned?	4.13	
Recyclable?	4.43	
Non-toxic?	5.32	
Repairable?	5.39	
Energy efficient?	4.77	
Reliable?	3.99	
Accessible?	5.25	
Regenerative?	3.38	
Habitat-safe?	5.94	
User-defined ...		
User-defined ...		
	4.30	24.88%
		100.00%

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Instructions

Enter survey responses to the right of this page. Responses are computed as opinion multiplied by relevance, and are in the range -10 to +10. There is provision for 1,000 responses to be entered against each question. Specify the total responses in Cell K38.

Further Information

https://bond.edu.au/cccr
(including latest updates)

Disclaimer

Every attempt has been made to use unbiased evidence-based data (cells with light grey shading) in this study where possible.

i3d3 RANKING	25	Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

CONSEQUENCES	Project Initiate	Project Implement	Project Influence	Score (%)
Financial (long life)	-70	-35	65	**-13**
Social (loose fit)	41	-35	66	**24**
Ethical (least pain)	100	0	67	**56**
Environmental (low energy)	58	-15	62	**35**
Score (%)	**32**	**-21**	**65**	**25**

The HZMB is a megaproject, and one of the most iconic infrastructure investments of this century. It is the longest sea crossing in the world. Situated in the Pearl River Delta and owned by the People's Republic of China, it connects Hong Kong, Zhuhai and Macau with a six lane toll road including elevated bridge deck, three large cable-stay spans, artificial islands, undersea tunnel, link roads and border control facilities for each region. The engineering challenge was extremely complex and ambitious. However, its contribution to the economy of the region, to tourism and to the productivity of transport and trade is significant. It is a beacon of ingenuity and human endeavour, but took nearly nine years to build. During this time, 20 workers were killed on the project, and there were over 500 injuries reported. Some news stories point to the bridge being a 'white elephant', as work has already commenced on another sea link between Shenzhen and Zhongshan (including a high speed rail service) that is now expected to reduce demand for HZMB. This is on top of much lower demand figures than expected (currently 2,416-4,791 vehicles/day recorded over first year of operation, down from 33,100 in feasibility study), caused by complexities in immigration, high cost of road toll (RMB 200/trip), triple certification required for third party insurance across three jurisdictions, and current civil unrest in Hong Kong. In the latter case, the bridge is now seen by some as having a political agenda to more tightly connect the special administrative regions to Mainland China control.

i3d3 ranking

Success is measured on a scale of -100 to +100, where the border of success and fail is set at zero. The above table shows success according to project phases and consequences. Each value in this table is assigned equal weight. Light red shaded cells are problems. Success can be a surrogate for wider project 'quality'.

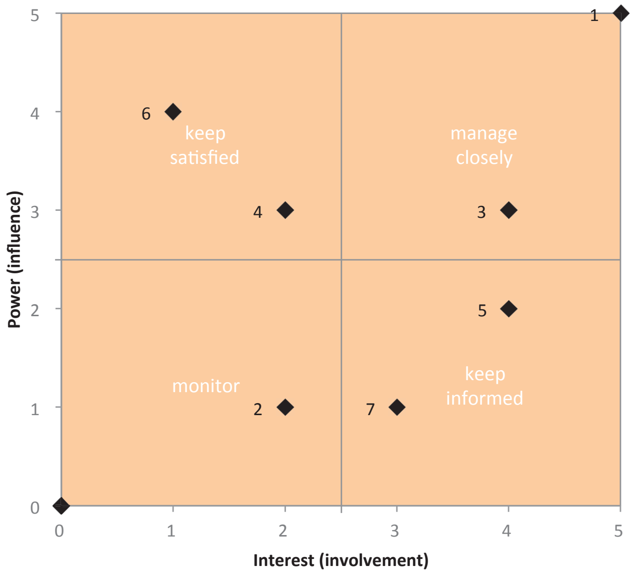
NET BENEFIT	30	Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

BENEFIT REALIZATION winners 5 losers 2

Stakeholders:

	stakeholder ID#	power 1-5	interest 1-5	expected value (%)
Owner/sponsor	1	5.0	5.0	-70
Local community	2	1.0	2.0	41
Shareholders/authorities	3	3.0	4.0	100
Environmentalists	4	3.0	2.0	58
Project team	5	2.0	4.0	-21
Client/end-user	6	4.0	1.0	65
Wider society	7	1.0	3.0	40
	8			
	9			
	10			
	11			
	12			

key: 1=minimal 2=low 3=moderate 4=high 5=extreme

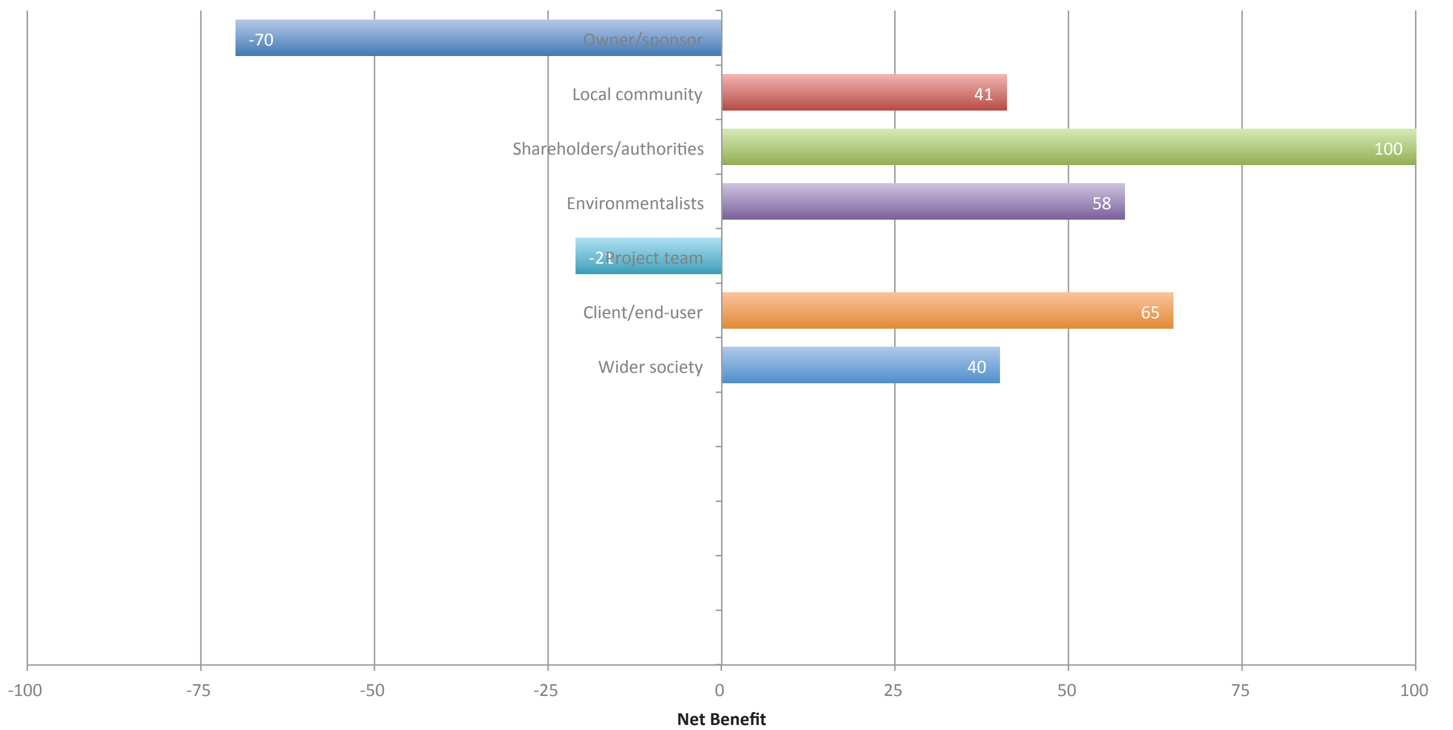


Benefit Register:

	benefit ID#	T/I	D/I	P/E	S/M/L	stakeholder ID#	expected value (%)	realized? Y/N	comments
BCR success score (design) > 0	1	T	D	P	M	1	-70	Y	Project has a negative BCR
LPS success score (design) > 0	2	I	I	P	S/M/L	2	41	Y	
RAR success score (design) > 0	3	T/I	D/I	P	M/L	3	100	Y	
EFP success score (design) > 0	4	I	I	E	L	4	58	Y	
PDS success score (deliver) > 0	5	T	D	P	S	5	-21	Y	Project delivery was considerably delayed
EUS success score (delight) > 0	6	T	D/I	P	S/M/L	6	65	Y	
SDG humanity index > 0	7	I	I	P/E	L	7	40	Y	
	8								
	9								
	10								
	11								
	12								

key: tangible / intangible; direct / indirect; planned / emergent; short term / medium term / long term

mean = 30%



HUMANITY INDEX 40 | Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOAL (SDG) CONTRIBUTIONS | benefit justification

Financial: 0

investments in infrastructure are crucial to achieving sustainable development

HZMB was financially unviable and delivered well over budget, but otherwise would have contributed to SDG#9 if its financial performance was better.

not eligible | 9

Social: 0

Not applicable.

not eligible

Ethical: 20

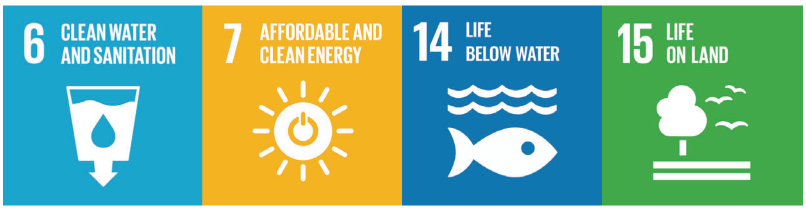
access to justice for all, and building effective, accountable institutions at all levels

HZMB serves as an important and unifying piece of infrastructure connecting three different Chinese cities with three different governance systems.

enter primary SDG# here > | 16

Environmental: 20

careful management of this essential global resource is a key feature of a sustainable future



The project had minimal impact on the long-term environmental quality of the Pearl River Delta.

not eligible | 14

revitalize the global partnership for sustainable development

HZMB was a nation-building project of the People's Republic of China, and involved collaboration with the Special Administrative Regions of both Hong Kong and Macau. It required design and delivery expertise from a large number of international enterprises.

enter SDG#17* here > | 17

*this SDG is only available when the complexity score (delivery) is 12 or more

DESIGN (DSS) 32 Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

SUCCESS FACTOR feasible -70 useable 41 achievable 100 sustainable 58

Profit:

Benefit-cost ratio (BCR) **0.2964**

year	benefit	discounted benefit	cost	discounted cost
0		-	120	120
1		-	3,500	3,431
2		-	5,500	5,286
3		-	6,500	6,125
4		-	7,000	6,467
5		-	6,500	5,887
6		-	5,500	4,884
7		-	3,500	3,047
8	672	573	34	29
9	672	562	34	28
10	672	551	34	28
11	672	540	34	27
12	672	530	34	26
13	672	519	34	26
14	672	509	184	139
15	672	499	34	25
16	672	489	34	24
17	672	480	34	24
18	672	470	34	24
19	672	461	34	23
20	672	452	34	23
21	672	443	184	121
22	672	434	34	22
23	672	426	34	21
24	672	418	34	21
25	672	409	34	20
26	672	401	34	20
27	672	393	34	20
28	672	386	184	105
29	672	378	34	19
30	672	371	34	19
		10,695		36,081

discount 2.00 %
currency RMB (million)

assume BCR (override)

Notes
Benefits and costs should exclude intangible cash flows
Discount rate is net of inflation (i.e. real discount rate)
Cash flows are expressed in Year 0 terms
BCR can be entered directly using 'assume BCR' cell
Immigration operating costs are not included in the project
Life expectancy of bridge estimated at 120-170 years
The project commenced in December 2009
Feasibility study downgraded to 9,200 vehicles/day
Average toll is RMB 200 per vehicle
Maintenance, repair and energy costs assumed at 5% of income
Road resurfacing undertaken every 7 years

People:

Statement: *I support this proposed project*

Local project support (LPS) **0.8252**

strongly disagree	disagree	no opinion	agree	strongly agree	responses
2	11	11	58	21	103

sample N/A
return rate 0%

Politics:

Risk and reward (RAR) **2.2436**

ID	reward (opportunities) - * must complete 5	probability 1-3	consequence 1-3	risk level 1-9
A*	Key link between HK and 9 other Guangdong cities	3	3	9
B*	A megaproject of Chinese national pride	2	1	2
C*	Increased trade, tourism and visitor flow	2	3	6
D*	33,100 vehicles and 171,800 passenger trips/day	2	3	6
E*	Economic prosperity for the Guangdong province	2	3	6
F	Social inclusion for people in the region	3	2	6
G				
			mean	5.83

ID	risk (threats) - * must complete 5	probability 1-3	consequence 1-3	risk level 1-9
A*	Competition from future road/rail links	2	2	4
B*	Lower traffic volumes than expected	1	3	3
C*	Immigration complexities (1 country, 3 policies)	2	1	2
D*	White elephant label	1	1	1
E*	Toll charges	3	1	3
F				
G				
			mean	2.60

Planet:

Ecological footprint (EFP) **14.0000**

environmental categories (impacts)	extreme (0 stars)	high (1 star)	moderate (2 stars)	low (3 stars)	minimal (4 stars)	regenerative (5 stars)
non-renewable energy demand (embodied carbon)		Y				
water quality impacts			Y			
air pollution	Y					
natural resource depletion					Y	
biodiversity loss					Y	
non-degradable or non-recyclable waste to landfill				Y		
	1	1	1	1	2	0

DELIVER (PDS)	-21	Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

SUCCESS FACTOR	within budget	-35	on schedule	-35	as specified	0	no surprises	-15

Cost:

	planned	actual		change
Construction (RMB million)	38,120.00	48,070.00		26.10%

Time:

	planned	actual		change
Onsite activity (calendar month)	84.00	106.00		26.19%

Scope:

	planned	actual		change
Length of journey (km)	55.00	55.00	✔	0.00%

Risk:

	planned	actual	change
√ mean risk level (1-3)	2.14	2.35	9.35%

KPIs

-100 ≤ PDS ≤ 100

		change
value (scope/cost)		-20.70%
efficiency (cost/time)		-0.07%
speed (scope/time)		-20.75%
innovation (risk/cost)		-13.29%
complication (time/risk)	✔	15.40%
impact (scope/risk)		-8.55%
profit (scope^2/cost^2)		-37.11%
people (scope^2/time^2)		-37.20%
planet (scope^2/risk^2)		-16.36%
progress (TBL mean)		-30.23%

COMPLEXITY

27

chaotic

	1-3
X: scale	3
Y: uncertainty	3
Z: stakeholders	3

Planned risk events

Probability and consequence are assessed after any mitigation strategies have been included in scope, cost and time estimates

ID	risk event - * must complete 5	planned probability 1-3	planned consequence 1-3	planned risk level 1-9
A*	Industrial accidents	3	3	9
B*	White dolphin impacts near Lantau Island constructions	2	2	4
C*	Complicated construction procedures in open sea	2	2	4
D*	Erosion of artificial islands at tunnel mouth	2	1	2
E*	Delays and overrun due to engineering complexity	2	2	4
F	NEW (ACTUAL) RISKS:			
G	Fake concrete test results by corrupt contractors			
H				
I				
J				
K				
L				
M				
N				
O				
P				
Q				
R				
S				
T				
			√ mean	2.14

Actual risk events

Consequence is determined based on final project outcomes, and should include any unanticipated risk events

ID	risk event - * must complete 5	actual probability 1-3	actual consequence 1-3	actual risk level 1-9
A*	Industrial accidents	3	3	9
B*	White dolphin impacts near Lantau Island constructions	3	1	3
C*	Complicated construction procedures in open sea	3	2	6
D*	Erosion of artificial islands at tunnel mouth	3	2	6
E*	Delays and overrun due to engineering complexity	3	2	6
F	NEW (ACTUAL) RISKS:	3	-	
G	Fake concrete test results by corrupt contractors	3	1	3
H		-		
I		-		
J		-		
K		-		
L		-		
M		-		
N		-		
O		-		
P		-		
Q		-		
R		-		
S		-		
T		-		
			√ mean	2.35

DELIGHT (EUS)	65	Hong Kong - Zhuhai - Macau Bridge (HZMB), Pearl River Delta, PRC

SUCCESS FACTOR	desirable	65	adaptable	66	practicable	67	serviceable	62

Attractiveness:

	mean	influence
Nice to look at?	3.70	
High quality?	3.08	
Profitable?	2.35	
Well-designed?	3.39	
Valuable?	4.36	
Prestigious?	3.71	
Durable?	4.28	
Popular?	3.49	
Joyful?	3.78	
Unique?	4.30	
User-defined ...	7.17	
User-defined ...	7.67	
	4.27	25.41%

Flexibility:

	mean	
Versatile?	3.84	
Easily modified?	2.52	
Able to be customized?	3.46	
Multi-use?	4.08	
Transportable?	4.15	
Better with age?	3.69	
Modular?	4.67	
Scalable?	4.70	
Technically clever?	4.10	
Timeless?	4.64	
User-defined ...	7.17	
User-defined ...	8.00	
	4.59	27.27%

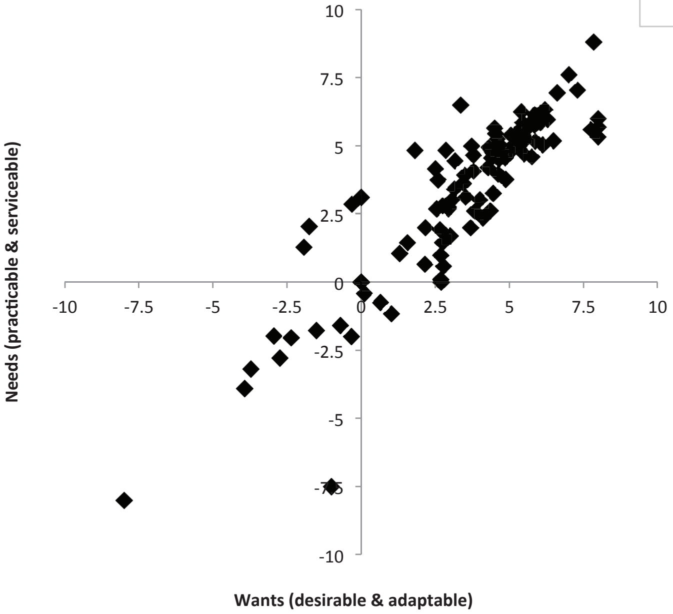
Fit for Purpose:

	mean	
Functional?	4.53	
Appropriate?	4.30	
Robust?	4.31	
Safe?	4.68	
Healthy?	4.32	
Problem-solving?	4.00	
Easy to use?	4.17	
Affordable?	5.11	
Comfortable?	4.66	
Ethical?	4.13	
User-defined ...	6.00	
User-defined ...	5.86	
	4.67	27.78%

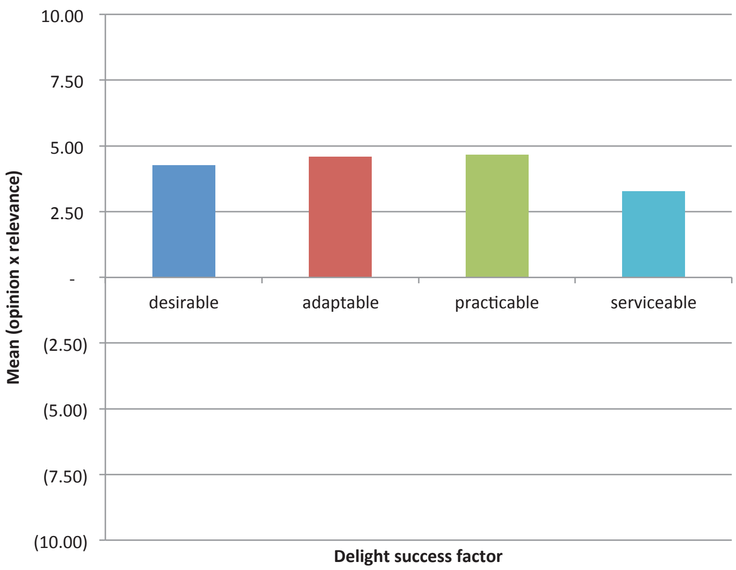
Enduring:

	mean	
Low maintenance?	1.32	
Easily cleaned?	2.69	
Recyclable?	3.59	
Non-toxic?	2.66	
Repairable?	4.32	
Energy efficient?	3.51	
Reliable?	3.82	
Accessible?	3.31	
Regenerative?	2.81	
Habitat-safe?	2.10	
User-defined ...	4.75	
User-defined ...	4.57	
	3.29	19.54%
		100.00%

Q1



percent Q1	82.52	%
total responses	103	



sample		N/A
return rate		0%
expected delight (LPS)		41%
actual delight (EUS)	✔	65%

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Instructions

Enter survey responses to the right of this page. Responses are computed as opinion multiplied by relevance, and are in the range -10 to +10. There is provision for 1,000 responses to be entered against each question. Specify the total responses in Cell K38.

Further Information

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(including latest updates)

Disclaimer

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APPENDIX 2

Page 275 - 293

The following pages include the Management Maturity Model (MMM) paper which can also be retrieved from this link: https://doi.org/10.5130/AJCEB.v16i4.5028

A Management Maturity Model (MMM) for project-based organisational performance assessment

Craig Langston[1] **and Amir Naser Ghanbaripour** [2]

[1]*Bond University, Australia*
[2]*Iran University of Science and Technology*

Abstract

Common sense suggests that organisations are more likely to deliver successful projects if they have systems in place that reflect a mature project environment based on a culture of continuous improvement. This paper develops and discusses a Management Maturity Model (MMM) to assess the maturity of project management organisations through a customisable, systematic, strategic and practical methodology inspired from the seminal work of Darwin, Deming, Drucker and Daniel. The model presented is relevant to organisations, such as construction and engineering companies, that prefer to use the Project Management Body of Knowledge (*PMBOK™ Guide*) published by the Project Management Institute (PMI), but without the disadvantages of excessive time and cost commitments and a 'one size fits all' approach linked to rigid increments of maturity. It offers a game-changing advance in the application of project-based organisational performance assessment compared to existing market solutions that are unnecessarily complex. The feasibility of MMM is field-tested using a medium-sized data centre infrastructure firm in Tehran.

APPENDIX 2

Keywords: Project management, delivery success, organisation maturity modelling, PMBOK

Paper type: Research article

Introduction

All kinds of organisations, whether they be government agencies, private companies, charitable institutions or other collectives, spend time and effort to define their short, medium and long term objectives and the strategies that help them to be achieved (Demir and Kocabaş, 2010). The essence of project management is a direct outcome of what is the required scope of work and how well it is implemented (Silva et al., 2014). The contemporary need for project management, and the contribution that is possible from deploying a structured methodology, regardless of industry sector or discipline, is well documented. Project management has become both a key activity of organisational management and has enabled success, balance and harmony to be realised by global organisations (Hutson, 1997).

The definition of organisational maturity refers to operations that are in perfect synergy to achieve strategic objectives (Silva et al., 2014). Maturity models are considered to be tools that simulate specific aspects of capability and define the qualitative attributes that characterise competence at a particular level of performance (Demir and Kocabaş, 2010). These levels are typically sequential (Kohlegger et al., 2009). The origins of maturity models lie in the discipline of total quality management. They require a thorough understanding of an organisation's current

Citation: Langston, C. and Ghanbaripour, A.N. 2016. A Management Maturity Model (MMM) for project-based organisational performance assessment. *Construction Economics and Building*, 16(4), 68-85. DOI: http://dx.doi.org/10.5130/AJCEB.v16i4.5028

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Publisher: University of Technology Sydney (UTS) ePress

strategic position and where it aims to be in the future (Brookes and Clark, 2009). A maturity model provides a framework for systematic and continuous performance improvement.

Organisations are considered more likely to deliver successful projects if they have systems in place that reflect a mature project management environment based on a culture of continuous improvement (Crawford, 2011). Over the years research has been undertaken to develop frameworks that objectively measure organisational maturity (Cooke-Davies, 2004; Nesensohn et al., 2014). Popular frameworks in widespread use are generally complex and require a high degree of expertise and time when deployed in practice.

Nesensohn et al. (2014) found that over the past two decades there has been a rapid growth in publications about organisational maturity. Based on a search of four key databases (i.e. Business Source Complete; Emerald; Scopus; Discover) from 1990 to 2013, they found that the number of relevant articles per database has increased every year. There has been a simultaneous growth in maturity models over this period.

The aim of this paper is to set out a management maturity model based on the plan-do-check-act (PDCA) cycle to assess the maturity and performance of organisations in project management environments. This includes a review of relevant literature, reflection of criticisms, model development based on a unique conceptual approach, and field testing of this proposed solution in a real organisation, followed by discussion of implementation feedback and final conclusions.

Literature review

The achievement of consistent project management excellence is assisted by mature organisational systems and processes. The understanding of maturity, however, is often a subjective concept (Pretorius et al., 2012). Maturity models typically have a conceptual underpinning with constituent components that define the progressive development of capabilities, and ideally outline the processes that organisations could implement to achieve a more mature state (PMI, 2013). Maturity improvements require a concerted effort of continuous review and reflection at an organisational management level.

It should be noted that maturity models, like the discipline of project management itself, apply generically to any industry sector. For example, no compelling consensus was found in the literature that organisations undertaking engineering and construction projects require a bespoke solution. Some models have certainly emerged from a particular sector, such as software development, but their subsequent application has been demonstrated over time to have a much broader appeal.

There are now a number of maturity models operating within a range of business management fields, and in particular within the discipline of project management. The three main players in project management are discussed below.

Capability Maturity Model Integration (CMMI)

The Capability Maturity Model Integration (CMMI) project had its origins in a number of other tools that were developed from 1986 and were combined together in 1993 to form a single integrated tool (de Souza and Gomes, 2015). According to the CMMI Institute, over 10,500 individual CMMI appraisals have now been undertaken globally since 2007, making it the most successful maturity tool available. The CMMI Institute operates through a network of CMMI partners, which comprise trained and certified organisations and individuals providing official training programs, appraisals and other consulting services. The CMMI Institute Partner Network enables global reach to organisational clients and is the only avenue for authentic CMMI services outside of the institute itself (http://cmmiinstitute.com/about-cmmi-institute).

Building on an organisation's business performance objectives, CMMI provides a set of practices for improving processes, resulting in a continuous improvement system that paves the way for better operations and performance. CMMI applies to organisations that undertake software development, systems engineering and product development through the use of a single tool to assess maturity or capability, and provides direction while developing more sophisticated processes (Staples et al., 2007; Pane and Sarno, 2015). There are five maturity levels used in the 'staged' representation of CMMI:

1. *Initial*: Processes are unpredictable, poorly controlled and reactive
2. *Managed*: Processes are characterised for projects and are often reactive
3. *Defined*: Processes are characterised for the organisation and are proactive
4. *Quantitatively managed*: Processes are measured and controlled
5. *Optimising*: There is a focus on process improvement

An immature organisation would display characteristics such as process improvisation, approved processes being ignored, reactive as opposed to proactive decisions, unrealistic budget and schedule constraints, quality sacrificed for schedule, and no objective measure of quality. In contrast, the characteristics of a mature organisation include inter-group communication and coordination, work accomplished according to plan, practices consistent with processes, processes updated as necessary, well-defined roles/responsibilities, and formal commitment from management.

CMMI can also be used as 'continuous' representation, where six capability levels apply instead. In this case, 'level 1: initial' is subdivided into 'level 0: incomplete' and 'level 1: performed'. The remaining levels are the same. There is little significance between the meaning attached to maturity and capability.

Some studies state that there is a problem with the adoption of CMMI by organisations, and facilitation of the assessment is required to avoid wasting resources (Hardgrave and Armstrong, 2005; Staples and Niazi, 2010; Allué et al., 2013). According to Allué et al. (2013), one way of achieving facilitation is to provide organisations with tools or software products that make the adoption of CMMI easier. Few tools support all of the types of CMMI-related activities however as the support level that is provided is often limited, and a tool's ability to be customised according to the users' needs is quite small (Musat et al., 2010). CMMI is compatible with the AGILE project management methodology (Jiang et al., 2004).

Portfolio, Program & Project Management Maturity Model (P3M3)

The Office of Government Commerce (OGC) fostered the development of a government maturity standard called the Portfolio, Program and Project Management Maturity Model (P3M3), aligned to the PRINCE2 methodology (González et al., 2007). According to Sowden et al. (2008:8), *"P3M3 is not simply about isolated, here-and-now assessments – it also acts as a roadmap for ongoing improvement and progression towards realistic and achievable goals that are suitable for your business needs and aspirations"*. González et al. (2007) states that P3M3 focuses on the addition of portfolio and program management domains to earlier versions of the model, helping to expand emerging processes of project complexity that contribute to overall success. The levels of maturity in P3M3 are effectively identical to those for CMMI, and are described in Table 1.

P3M3, like PRINCE2, is a joint venture between OGC and Axelos and has a strong support base in the United Kingdom. It is built on seven process-related perspectives that exist in project, program and portfolio domains and is assessed at five levels of increasing maturity (https://www.axelos.com/best-practice-solutions/p3m3/what-is-p3m3). These perspectives are:

1. Organisational governance
2. Management control

3. Benefits management
4. Risk management
5. Stakeholder management
6. Finance management
7. Resource management

Young et al. (2014:220) argue that one deficiency of the P3M3 model is that it *"uses a single number to represent maturity at the project, program and portfolio level, with this number being the lowest score in either generic attributes or the process perspectives across each sub-model* […] *the single number reported is therefore misleading and will generally report a lower level of maturity than what is present in an organisation, not only painting a poorer picture than what might exist* [… but] *disregarding the relative closeness of the next higher level"*. Another shortcoming they mention is that the 'generic attributes' evaluated in all three P3M3 domains are claimed as essential to achieving improvement in project management maturity. It is doubtful however whether these generic attributes are appropriate for program and portfolio management domains, which are typically more complex than standalone project management (Artto et al., 2009; Young et al., 2014).

Table 1: P3M3 maturity levels (Sowden et al., 2008)

Maturity Level	Portfolio Management	Program Management	Project Management
Level 1: awareness of process	Does the organisation's Executive Board recognise programs and projects, and maintain an informal list of its investments in programs and projects?	Does the organisation recognise programs and run them differently from projects?	Does the organisation recognise projects and run them differently from its ongoing business?
Level 2: repeatable process	Does the organisation ensure that each program and/or project in its portfolio is run with its own processes and procedures to a minimum specified standard?	Does the organisation ensure that each program is run with its own processes and procedures to a minimum specified standard?	Does the organisation ensure that each project is run with its own processes and procedures to a minimum specified standard?
Level 3: defined process	Does the organisation have its own centrally controlled program and project processes and can individual programs and projects flex within these processes to suit particular programs and/or projects. Does the organisation have its own portfolio management process?	Does the organisation have its own centrally controlled program processes and can individual programs flex within these processes to suit the particular program?	Does the organisation have its own centrally controlled project processes and can individual projects flex within these processes to suit the particular project?
Level 4: managed process	Does the organisation obtain and retain specific management metrics on its whole portfolio of programs and projects as a means of predicting future performance? Does the organisation assess its capacity to manage programs and projects and prioritise them accordingly?	Does the organisation obtain and retain specific measurements on its program management performance and run a quality management organisation to better predict future performance?	Does the organisation obtain and retain specific measurements on its project management performance and run a quality management organisation to better predict future performance?
Level 5: optimised process	Does the organisation undertake continuous process improvement with proactive problem and technology management for the portfolio in order to improve its ability to depict performance over time and optimise processes?	Does the organisation undertake continuous process improvement with proactive problem and technology management for programs in order to improve its ability to depict performance over time and optimise processes?	Does the organisation undertake continuous process improvement with proactive problem and technology management for projects in order to improve its ability to depict performance over time and optimise processes?

Organisational Project Management Maturity Model (OPM3)

Another important model used in the project management discipline is OPM3. Developed by a team of volunteers from the PMI between 1998 and 2013, it is suitable for organisations of any size, location or practice environment. It aims to enumerate the level of maturity of projects and practices, based on best practices as a methodology for assessment. Similar to P3M3, it sets out requirements to assist in the development of better capabilities that underpin projects, programs and portfolios and assist organisations to realise strategic objectives through the delivery of successful outcomes (PMI, 2013; Silva et al., 2014).

This model supports both continuous process improvement to diagnose existing organisational systems, and uniquely highlights potential problems or deficiencies including the detailed design of necessary improvements (Fahrenkrog et al., 2003). It is aligned specifically to the widely recognised PMBOK methodology. OPM3 compares organisational activities with a large number of standardised best practices, measuring them in project, program and portfolio management contexts by examining capabilities and related outcomes. Organisations are then classified into four levels of maturity development, not five as embedded in CMMI and P3M3, for each process area in each domain (Pinto and Williams, 2013):

1. *Standardise:* Structured processes are adopted
2. *Measure:* Data is used to evaluate process performance
3. *Control:* Control plan developed for measures
4. *Continuously improve:* Processes are optimised

Cooke-Davies (2004) state that the basic ‘building blocks’ of OPM3 are:

1. Use of best practices related to organisational project management
2. Core capabilities that are needed to support the achievement of each best practice outcome
3. Observable evidence that attests to the existence of specific capabilities that are routinely applied within an organisation
4. Key performance indicators (KPIs) and other metrics that provide a basis for objective outcome measurement
5. Pathways that identify the capabilities that aggregate to attainment of relevant best practice outcomes

Importantly, OPM3 creates and advocates the critical connection between organisational strategy and successful projects, as illustrated in Figure 1.

Figure 1: Core OPM3 philosophy (PMI, 2013)

OPM3 is by far the most sophisticated of the identified maturity models in the discipline of project management, but also the most resource intensive (Hillson, 2003; Cooke-Davies, 2004; Backlund et al., 2014). Current maturity models are unlikely to ever be the ‘silver bullet’ that one might hope for because they typically:

1. Lack a well-researched and theoretical understanding of what is needed for successful project management outcomes

2. Are founded on the assumption that there is an ideal path of development towards maturity that most organisations should pursue regardless of discipline area, project scope, competitive marketplace context or chosen strategy
3. Must walk a fine line *"between the 'Scylla' of over-simplification and the 'Charybdis' of excessive complexity"* (Cooke-Davies, 2004:1252)

OPM3 is currently under review and is the subject of deep unrest between some of the certified assessors and the PMI over the current direction and marketing of a product that comprises shared intellectual property. Without full access to the best practice standards, which are the heart of the model, assessors are unable to use this tool in practice. It is likely that in the years that lie ahead OPM3 will be significantly changed and possibly rebranded.

Other models

A number of other maturity models discovered online were also reviewed:

1. *The Berkeley Project Management Maturity Model (PM2):* http://www.ce.berkeley.edu/~ibbs/yhkwak/pmmaturity.html
2. *Kerzner PM Maturity Assessment:* http://www.iil.com/kpm3/default.asp
3. *PM Solutions Project Management Maturity Model (PMMM):* http://www.pmsolutions.com/resources/view/what-is-the-project-management-maturity-model/
4. *The SUKAD Seven Elements of Project Management Maturity (7Es):* http://sukadway.sukad.com/project-management-maturity-model-overview)
5. *Onemind:* www.onemind.co.uk
6. *Standardised Process Improvement for Construction Enterprises (SPICE):* http://usir.salford.ac.uk/9965/1/280_Jeong_KSStructured_Process_Improvement.pdf
7. *IPMA Delta Module O (Organisation):* http://www.ipma.world/certification/certify-organisations/deltacompetence-classes/

General criticisms

One of the criticisms of applying the current models in organisations is the focus on explicit project management knowledge areas rather than intangible assets, which are less obvious but nevertheless contribute to a mature project management capability (Jugdev and Thomas, 2002). Intangible assets include context-specific outcomes such as customer involvement and implicit human factors including creativity, integrity and trust (Pasian et al., 2012; Backlund et al., 2014). Another problem with many models is the complexity of their frameworks, which may prevent potential users to implement them on the basis of time and cost commitment (Crawford, 2011).

Jugdev and Thomas (2002) also summarised some common criticisms of maturity models as comprising:

1. The models are mostly inflexible to change and ongoing improvements and are not able to address specific areas of specialisation
2. The models are often orientated towards identification of problems rather than solving problems
3. The models do not take account of the rapid pace of change and emerging technologies and innovative processes or practices adopted by organisations over time
4. The structured levels of maturity models do not propose sufficient detail to assess progress achievement
5. The models methodologies are largely mono-disciplined, disconnected from practice, and at times overwhelming
6. The models mostly ignore the human resource or operational aspects

Maturity models often have a limited theoretical basis and lack conceptual underpinning (Backlund et al., 2014). A major research project by Thomas and Mullaly (2008) into the benefit of project management identified the significance of 'fit' between implementation of projects and organisational strategy, including the impact of internal and external contexts. Mullaly and Thomas (2010) also highlight that this contradicts lessons from contingency theory, suggesting that different organisational configurations can be successful provided the strategies are consistent with their environment. In other words, maturity models need to provide a bridge between project success and organisational strategy. Crawford (2011:1) makes the following observation:

> *"Project management is now recognised as an organisational capability and there are numerous generic 'maturity' models providing one size fits all approaches to what is considered to be 'best practice'. Both maturity models and best practices are problematic. Maturity models typically suggest that all firms must strive to progressively achieve prescribed levels of practice across the same range of 'best' practices. But what constitutes best practice for whom and under what circumstances? If we look at an organisation's project management systems, although they may have similarities across firms, they are operating in different contexts, driven by different strategies. What may be best for some may not be best for others."*

The literature highlights a situation where the dominant market solutions to organisational maturity each have disadvantages that make them too rigid (one size fits all), deterministic (based on hierarchical assessment), misaligned to objectives (not strategic) and impractical (disconnect to project success). In addition, existing market solutions are complicated and resource intensive.

Given the above, it is suggested that an appropriate management maturity model should be customisable by organisations (i.e. able to evolve according to their changing environment over time), systematic in its assessment of organisational capabilities (i.e. continuous improvement framework), aligned to organisational strategy at the level of project, program and portfolio (i.e. management by objectives), and relevant to project delivery success in practice (i.e. use of measurable critical success factors). There is opportunity to align the model to the PMBOK methodology given that OPM3 is the main player in this domain, yet OPM3 is extremely complicated, expensive (cost and time) and currently going through a tumultuous stage in its development.

Proposed Management Maturity Model (MMM)

Each of the key criteria mentioned above is examined in this section. Inspiration is drawn from the seminal work of Charles R. Darwin (1809-1882), W. Edwards Deming (1900-1993), Peter F. Drucker (1909-2005) and D. Ronald Daniel (1931-) for the design of the proposed Management Maturity Model (MMM). Intrinsic to the model's approach is the need for it to also be practical in the project management marketplace and hence capable of widespread adoption.

Customisable

The literature is clear that a 'one size fits all' approach to maturity assessment is flawed. Not only are organisations different, but they also operate in a wide range of industries that themselves are at different stages of maturity. It has always been a core objective of maturity models to enable comparison of organisations in the context of benchmarking against 'best practice'. What constitutes best practice in one industry, however, may not be appropriate in another. It is also a barrier to adoption if competitive advantage is lost through disclosure of levels of immaturity that might affect reputation and market position. A more confidential way to benchmark performance needs to be found.

Organisations evolve over time, and the strength of their capabilities dictates whether they are successful or unsuccessful. Maturity assessment needs to provide guidance on positive improvement and fix weaknesses that might lead to poor performance.

Charles Darwin is renown for his contribution to evolution theory. His research established that all species of life have descended from common ancestors over time. His scientific theory was that this branching pattern of evolution resulted from a process of natural selection, in which the struggle to survive is similar to selective breeding programs. Darwin published his theory of evolution together with compelling field evidence in his book *On the Origin of Species* (Darwin, 1859). By the 1870s, the scientific community and a significant proportion of the general public believed evolution was indeed true, but it took many more years before a broad consensus emerged that natural selection was the basis of evolutionary improvement and capable of explaining the diversity of life on Earth. Darwin has been characterised as being one of the most influential people in human history.

Using this concept, organisations can be viewed as 'species' that evolve and diversify. This is not a function of maturation, but their agility to deal with external forces and trends within the environment in which they operate. These influences change over time. Best practice is also fluid.

Generic capabilities and standard criteria for mature systems and performance is limiting and inflexible. A better approach is for organisations to understand their journey of maturity over time by assessing their own core strategic objectives. Benchmarking with others can take place through the sharing of relevant organisational objectives used by market leaders or innovators that describe capabilities that are considered critical to success. Rather than comparing maturity levels to benchmark best practice, organisations adopt capabilities that are compatible with their individual structure and vision. Customisable core strategic objectives and organisational capabilities should be a key tenet in the process of maturity assessment.

Systematic

The literature is also clear that maturity assessment must be systematic and evidence-based. Maturity by definition is a process of continuous improvement from a state of relative simplicity (or naivety) to one of sophistication and rigour. This process needs to be capable of translation into measurable evidence at each stage of development. The level of maturity of an organisation is a function of the number of capabilities that can be observed to operate routinely at high levels of optimisation. The underlying systems put in place form the evidence of a mature process.

Continuous improvement is both sequential and cyclical. It is sequential because there are fundamental steps that must take place to reach higher levels of performance, and cyclical because organisations need to be able to learn from their performances in order to further improve the underlying processes and systematically pursue optimal outcomes (Wysocki, 2004).

Edwards Deming is credited with the well-respected plan-do-check-act (PDCA) continuous improvement cycle (Wood and Wood, 2005). The PDCA (see Figure 2) built on the work from Walter Shewhart's book *Statistical Method from the Viewpoint of Quality Control* (Shewhart, 1939) to produce the plan-do-study-act (PDSA) cycle. Nevertheless, Deming worked closely with Shewhart to develop the idea of continuous improvement as part of a system where feedback from the process and customer is evaluated against organisational goals (Moen and Norman, 2012). Deming is the father of the total quality management movement.

Continuous improvement can be applied to all management activities including project and performance management (Du et al., 2008). For example, in PMBOK (2013), the process groups are an example of PDCA, demonstrating that project management processes are similar to other business processes when it comes to continuous improvement. The *PMBOK™ Guide* adopts six process groups for projects – planning (plan), executing (do), monitoring (check) and controlling (act) – fitting within the context of initiating at the start and closing at the end of the project life cycle. The heart of the PMBOK methodology is closely aligned to PDCA.

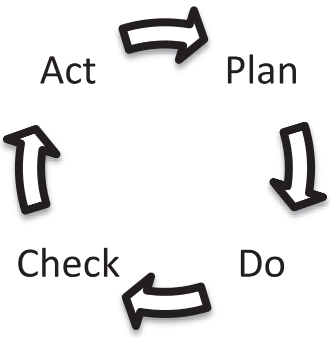

Figure 2: The PDCA continuous improvement cycle

For any project type, it is necessary to plan, do, check, and act. PDCA provides a robust and more tangible method for measuring maturity. The following analogy can be adopted for evidence-based assessment:

1. *Plan:* Establish targets
2. *Do:* Measure outcomes
3. *Check:* Assess performance
4. *Act:* Enhance protocols

Full maturity is reached when there is evidence of routine adoption of the above sequence in the underlying systems that support all of the appropriate organisational capabilities in the model. Rather than use a hierarchy of maturity levels, this approach highlights the need for nurturing a learning culture that aims to continuously improve (Stacey, 2003). A systematic cycle of organisational growth is thus supported.

Strategic

The literature refers to organisational capabilities as a framework in which maturity can be assessed. Capabilities are tied to core strategic objectives that are derived from a declared vision, mission and set of organisational values. The notion is that if capabilities are mature, then the achievement of organisational strategy is enhanced (Backlund et al., 2014). A large number of detailed capabilities, however, can inadvertently diminish their connection to strategy. It hence may be preferable to focus assessment on a smaller number of core capabilities (Nandyal, 2003).

The discipline of project management is commonly characterised as a combination of projects, programs (i.e. multiple aligned project) and portfolios (i.e. collections of projects and programs). It is likely that capabilities change and become more sophisticated on this continuum, and it provides an opportunity to demonstrate a maturation pathway from small scale (local projects) to large scale (global portfolios). In all cases, project management is achieved by the pursuit of objectives.

Peter Drucker is credited with the concept of management by objectives (MBO). His work contributed to the practical and philosophical foundations of the modern business corporation and he is frequently described as the founder of modern business management. He was a writer, academic, business consultant and self-acclaimed 'social ecologist' who explored the way that people interact and organise themselves. MBO arose from his book *The Practice of Management* (Drucker, 1954). It is a model of management that aims to improve organisational performance by clearly articulating strategic objectives that are accepted by both management and staff. According to the theory, participation in goal setting and the development of action plans leads to higher levels of commitment towards organisational success, as well as alignment of objectives across all parts of the business.

There are countless ways to implement management by objectives in practice. One needs to set core strategic objectives and then break these down into progressive targets. Organisations that apply MBO frequently report higher rates for sales and improved worker productivity (http://smallbusiness.chron.com/examples-managerial-objectives-23790.html). Objectives can be defined at any level of an organisation – with collective or individual responsibility. Both enable the task at hand to be more attainable and help people to visualise what needs to be achieved and how this can happen. Objectives need quantifying and monitoring.

Organisational capabilities are similar to objectives and can be managed in the same way. These capabilities can be used to track performance in the quest to move from lower capability to higher capability over time (Dosi et al., 2000). Each capability requires a target goal to be established, outcomes to be measured, assessment of performance and the enhancement of systems and protocols where improvement is warranted.

Practical

The literature is clear that maturity models act as a bridge between organisational strategy and project success. What is not so clear is how to measure success in an objective and organisation-wide manner. Cooke-Davies (2002) highlights confusion between terms such as 'project success' (doing the right project) and 'project management success' (doing the project right), and between 'success factors' (that lead to success) and 'success criteria' (that evaluate success). In the latter case, the list is long and criteria/factors are often specific to particular project types and client objectives (Davis, 2014). Success criteria (such as KPIs) and success factors (such as core project constraints) are commonly linked (Westerveld, 2003).

Ron Daniel developed the concept of success factors in the 1960s during his long-term role as Managing Director of McKinsey & Co. The notion seems quite obvious: in any business environment certain factors will be critical to the achievement of success, and so logically if objectives associated with the factors are not realised, the business will fail – perhaps dramatically. The objectives are examples of success criteria, and often presented in the form of KPIs. Critical success factors were defined twenty year's later by John Rockart as success factors that are 'mission-critical' (Rockart, 1979; Bullen and Rockart, 1981). Daniel's work translates well to the discipline of project management where successful project delivery is always the main goal.

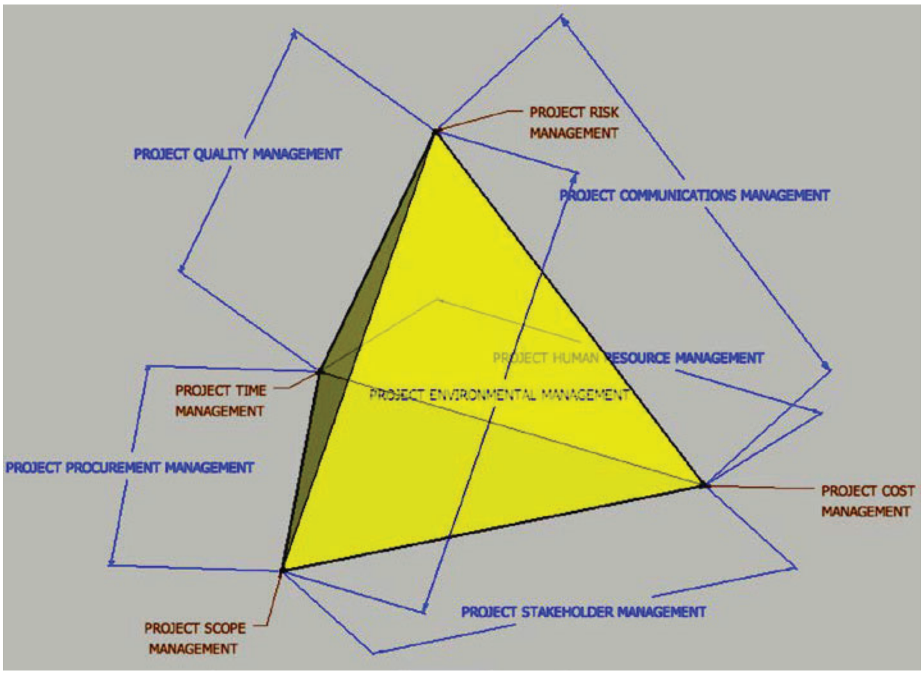

Figure 3: 3D Project integration model (Langston, 2013)

Langston (2013) employs success factors and criteria to explain what successful projects might look like. His AIPM and IPMA award-winning model (shown in Figure 3) for describing project integration is presented as a tetrahedron containing all knowledge areas existing in the *PMBOK™ Guide* (Fifth Edition), plus a new area of project environmental management that can recognise sustainability as an emerging aspect of modern project delivery (Ebbesen and Hope, 2013; Fernández-Sánchez and Rodríguez-López, 2010; Hwang and Ng, 2013). Langston contends his model can be deployed to measure the ability of project teams to deliver successful performances at all stages of the project life cycle. This is achieved through the identification of success factors (represented by the four vertices of the model) and success criteria (represented by the edges of the model). KPIs are derived from the model to describe the relationships between success factors. They are constructed so to be relevant to any project type as well as being capable of numeric measurement. Project Integration Management, a key knowledge area in the *PMBOK™ Guide*, is intended to ensure that the right balance between all parts of a project is achieved over the project life cycle, and is reflected in the 3D nature of the model itself.

This 3D project integration model includes six generic success criteria (KPIs) that are related to project delivery success (PDS). They comprise:

1. *Value:* This KPI is described as project scope divided by cost (objective: maximise). Value is assessed in the context of Project Stakeholder Management, including meeting specified expectations and fostering ongoing engagement. Scope is interpreted as an output and cost is interpreted as an input, therefore the more utility delivered per unit of cost the more value for money is realised.
2. *Efficiency:* This KPI is described as project cost divided by time (objective: maximise). Efficiency is assessed in the context of Project Human Resource Management, including leadership and team high performance. Cost is interpreted as an output (i.e. the value of work completed) and time is interpreted as an input, meaning that the more money expended per unit of time the more efficient is the project delivery process.
3. *Speed:* This KPI is described as project scope divided by time (objective: maximise). Speed is assessed in the context of Project Procurement Management, including outsourcing strategies and parallel supply chains. Scope is interpreted as an output, and time is interpreted as an input, such that the more utility provided per unit of time the faster the project delivery process.
4. *Innovation:* This KPI is described as project risk divided by cost (objective: maximise). Innovation is assessed in the context of Project Communications Management, including knowledge management and research-informed learning. Risk is interpreted as an output (innovation leads to development risks) and cost is interpreted as an input; therefore a higher level of risk per unit of cost reflects the search for better ways of doing things (i.e. extra risk is only warranted if competitive advantage is realised).
5. *Complication:* This KPI is described as project risk divided by time (objective: minimise). Complication (originally known as 'complexity') is assessed in the context of Project Quality Management, including being alert to excessive quality assurance paperwork and engineering over design. Risk is interpreted as an output and time is interpreted as an input, so a higher level of risk per unit of time is a sign of project difficulty that should be avoided during rollout.
6. *Impact:* This KPI is described as project risk divided by scope (objective: minimise). Impact is assessed in the context of Project Environmental Management, including awareness of adverse sustainability outcomes and unnecessary resource consumption. Risk is interpreted as an output and scope is interpreted as an input, meaning that a higher risk level per unit of utility reflects unwanted environmental disruption.

The key relationships between the four success factors (cost, time, scope and risk) and the six success criteria (value, efficiency, speed, innovation, complication and impact) are illustrated in

Figure 4. A 2D representation of the model is provided for ease of comprehension, but it converts into a 3D tetrahedron by 'folding' along the dotted lines. Success factors are equally weighted and are shown in upper case.

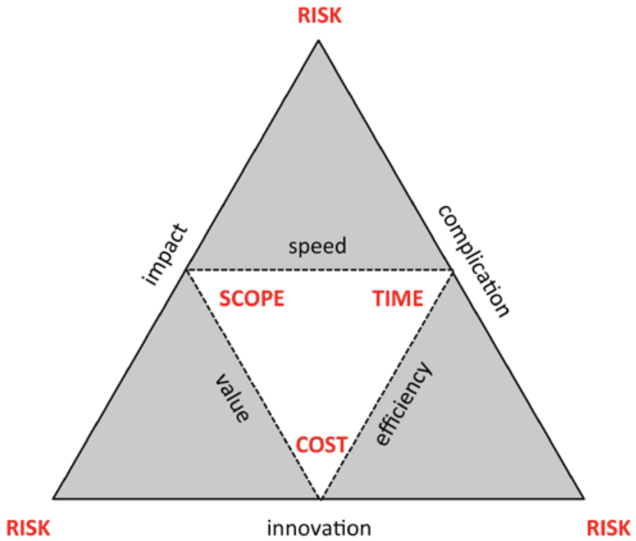

Figure 4: Success factors and success criteria (Langston, 2013)

Overall success (computed as the change in PDS between planned and actual performance) is given by the following formula (Langston, 2013):

$$Project\ Delivery\ Success\ (PDS) = \frac{s^3}{ctr}$$

where: s = scope baseline, c = cost baseline, t = time baseline and r = risk baseline

MMM design and testing

Drawing on the above issues, a new approach for the assessment of organisation maturity is constructed. It is based on the six KPIs for project delivery success (value, efficiency, speed, innovation, complication and impact) plus an overall KPI to take account of the combined effect of the four success factors (scope, cost, time and risk). Continuous improvement based on PDCA is the means for assessing maturity. Core objectives and capabilities for project, program and portfolio domains can be identified. These are customisable and therefore can differ from one organisation to the next. The full model, shown in Figure 5, is tested in the field based on a medium-sized data centre infrastructure firm in Tehran. The data was collected anonymously and as such the firm is referred to as 'example organisation'.

The example organisation uses a management by project approach as the basis for its business model. Within its niche market it is considered a medium-sized firm and employs approximately 270 people. It had a turnover last financial year of US$45 million and participated in numerous Iranian data centre projects as designer, supplier and constructor. The firm builds the data centre and then installs infrastructure using proprietary equipment sourced mainly from international suppliers.

The standard used for data centre design in the example organisation is ANSI/TIA942-2005 issued by the American Telecommunication Industry Association. In this standard, data centres are divided into different levels according to client requirements of reliability, infrastructure, construction structure, electric facilities and mechanical facilities (Ye et al., 2014). The example organisation is commissioned to design and build data centres according to client needs based on a rating/tier (1, 2, 3 or 4). A team of auditors certified by Uptime Institute (USA) perform monitoring compliance against the specified rating/tier.

DELIVERY SUCCESS			ORGANISATIONAL STRATEGY	ORGANISATIONAL CAPABILITY		EXAMPLE ORGANISATION 54%
ID	*KPI*	*Context*	*Core Objectives*	*Standalone Projects*	*Multiple Aligned Projects*	*Project/Program Collection*
1.0	value	stakeholder management	strategic alignment to build market share	1.1 repeat client work **4**	1.2 market positioning **2**	1.3 shareholder return **1**
2.0	efficiency	human resource management	gaining and retaining qualified staff	2.1 team training **3**	2.2 HR allocation **2**	2.3 performance appraisal **3**
3.0	speed	procurement management	supply chain logistics	3.1 PMO support **4**	3.2 project planning support **4**	3.3 foreign supplier relationship **2**
4.0	innovation	communications management	competitive advantage	4.1 information systems **1**	4.2 knowledge security **1**	4.3 R&D investment **4**
5.0	complication	quality management	achieving designed ANSI/TIA standard	5.1 compliance auditing **4**	5.2 learning environment **2**	5.3 international standards **3**
6.0	impact	environmental management	corporate social responsibility	6.1 minimum noise **3**	6.2 long term decision-making **3**	6.3 triple bottom line reporting **1**
7.0	overall	integration management	client satisfaction	7.1 minimising downtime **4**	7.2 integration of client sites **2**	7.3 reputation enhancement **1**

customisable by organisation

CONTINUOUS IMPROVEMENT

Score	*Stage*	*Description*
1	plan	establish targets
2	do	measure outcomes
3	check	assess performance
4	act	enhance protocols

assess continuous improvement against demonstrable evidence of organizational capability (0-4 points **progressive** capability, plus 4 points fully mature column, plus 4 points fully mature grid)

PROJECT **PROGRAM** **PORTFOLIO**

Figure 5: Proposed Management Maturity Model (MMM)

The example organisation shared documents relating to organisational capabilities in action, and facilitated interview responses from the Chief Executive Officer (CEO) and various program and project managers who work at the firm. This access helped to identify the firm's core strategic objectives and relevant capabilities aligned to each KPI. Points were assigned only where demonstrable evidence could be observed. This evidence was recorded electronically and archived in a database underpinning the case study methodology.

To illustrate the process, the KPI of 'value' is discussed in more detail. Value is interpreted in the context of stakeholder management. The core objective for this KPI is identified as 'strategic alignment to build market share'. In other words, value is strengthened when the performance of a project, program or portfolio is aligned to the strategic vision, mission and values of the organisation. This objective is then broken down into capabilities that enable repeat client work (project level), market positioning (program level) and shareholder return (portfolio level). These three capabilities are in increasing order of complexity and are scored according to evidence of progressive PDCA improvement. Evidence of 'Plan' equals 1 point, 'Plan+Do' equals 2 points, 'Plan+Do+Check' equals 3 points, and 'Plan+Do+Check+Act' equals 4 points. Missing a step in the PDCA sequence disables the scoring of further steps. The evidence collected from the example organisation is shown in Figure 6.

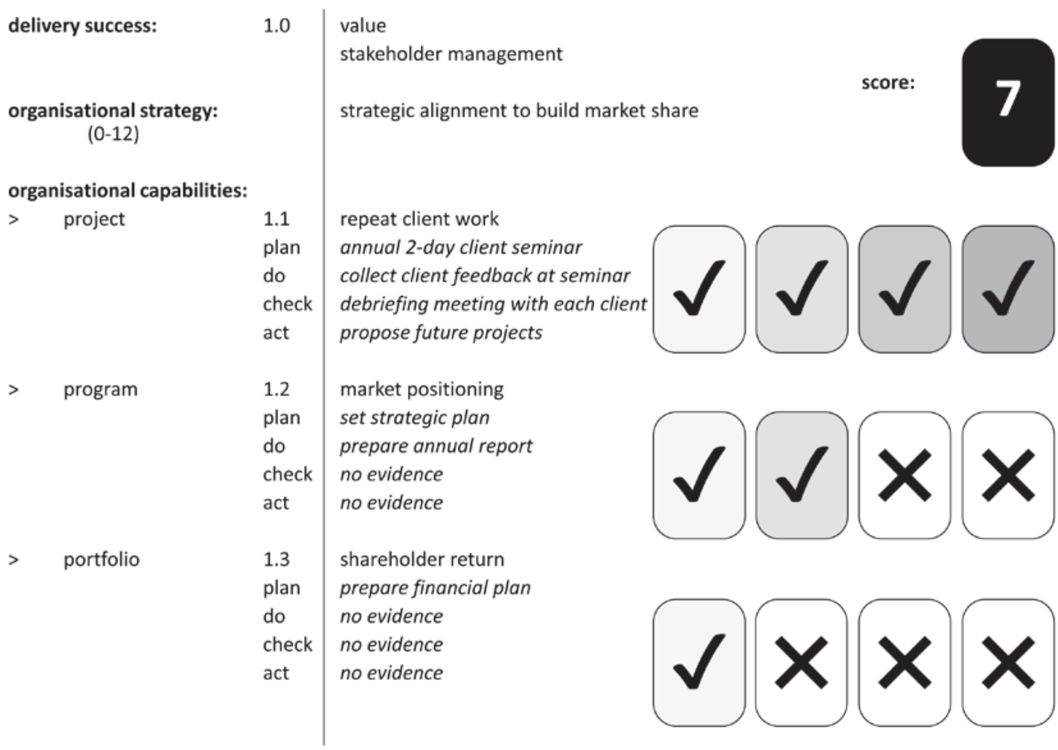

Figure 6: Example of identified case study evidence for 'value'

The maturity score for the example organisation is derived from a self-assessment process. Each domain can have a maximum score of 28. The radar diagrams show the level of maturity for project, program and portfolio domains, and the size of the mapped area gives a visual impression of where strengths and weaknesses lie (Jin et al., 2014). An extra 4 bonus points are awarded if a domain reaches this fully mature level. An extra 4 bonus points are awarded if all three domains are fully mature, and this would then equal 100 points overall (i.e. 100% maturity).

The case study results show that the firm has a maturity score of 54% based on their own defined strategy and capabilities. The radar diagrams highlight the weakest performance is in the domain of portfolio management. The firm's Project Management Office (PMO) has contributed to the stronger performance at the level of individual projects. Results from discussions with key personnel identify that the most important objective when operating in the data centre infrastructure industry is to grow market share, and this is achieved by close alignment of all activities with overall organisational strategy. In order to obtain feedback on the case study findings, the CEO was later interviewed about the process and whether it was useful to the organisation. His key comments are listed below (translated from Persian):

Our company is one the most active firms in the data centre infrastructure business in Iran. We have done several ICT projects within this industry and our first priority is to meet customer expectations in order to get repeat work from them. We have hired and trained a number of professional experts to help us in this regard.

The other aspects in which I feel we have developed maturity is our project management systems. Our PMO works hard on supporting project managers with useful templates and documents, and evaluating their performance. The project control team reviews data gathered from diverse projects located in different cities. However, there appear to be some weaknesses here. For instance, as there are an overwhelming number of stakeholders on our projects, an effective method of managing communications has not been achieved. Actually the problem runs deeper than that. The lack of an effective method leads to overlooking important lessons that would help to improve future projects.

Recently, in order to increase the company's technical capabilities, we established an R&D department that is working to minimise the downtime on our DC projects and use leading standard industry practices to satisfy auditors' requirements. This has proven very valuable to ensuring customer satisfaction.

Overall, I reckon we have to put more effort on building and developing our reputation within the industry, and controlling cost and time baselines to increase profit. I think that your approach to measuring our maturity is something we would like to continue to use, with your input and advice. We need to continually improve if we want to grow our current market share.

The CEO expressed high levels of satisfaction with both the method of maturity assessment and the practicality of its application in the office. The case study demonstrated that organisational strategy can be identified and capability can be demonstrated in terms of specific evidence collected during an independent audit. The outcome score provides a more precise measure of maturity than discrete hierarchical levels and involves up to 84 unique items of objective proof.

This case study highlights that maturity in the data centre infrastructure industry requires a set of capabilities that are somewhat different to what might be expected in other fields. For example, impact and environmental management are largely defined as relating to noise transfer to adjoining spaces and neighbouring properties. The firm scored well in terms of their investment in research and development (R&D) which is seen as critical to firm growth and market share. A comprehensive human resource (HR) allocation system exists but has not been updated for many years. A 360-degree appraisal is carried out annually to measure team performance. Overall, the audit was able to make recommendations for improving system maturity, such as devoting more effort towards better communication protocols to support competitive advantage. In particular, some of the benefits of R&D activity were not being captured and disseminated throughout the firm. Senior managers agreed that lessons learnt were not recorded in the PMO's system in a timely manner. Moreover, given the CEO manages the firm's portfolio himself, the assessor recommended that a team be established to handle this complex job in the near future.

MMM enables organisation maturity to be pursued via a customisable, systematic, strategic and practical approach. While it produces an overall score that can be used for internal trend analysis over time, the rigour of the process lies in the detailed assessment of individual capabilities. However, as capabilities are variables and organisation-specific, the model does not enable maturity to be compared across different organisations. Comparison is normally seen as a potential barrier to implementation in practice given that the maturity of an organisation (and hence the likelihood of achieving success in its endeavours) is not something to be broadcast to either the market or to one's competitors.

The approach used in MMM is facilitated by the involvement of experienced assessors. These assessors are critical in helping to realise the following benefits:

1. *Identifying appropriate objectives and capabilities:* These can be freely shared between organisations (via the assessors) since they reflect targets not performances
2. *Certifying the self-assessment process:* Evidence can be validated and audited by assessors to ensure probity
3. *Recommendations to enhance protocols:* An experienced assessor can suggest ways to address deficiencies and develop more mature systems to support business activities

Experienced assessors may be people who are already certifiers for other rival maturity models. It would be advantageous to use a small panel of assessors on every assessment. They are also likely to be drawn from senior project managers, directors of PMOs and qualified academics in the project management field. Their role includes auditing maturity evidence and providing advice on how to improve organisational systems and processes. International professional bodies such as PMI and IPMA, and national bodies such as APM and AIPM should act as brokers for putting organisations in touch with assessors, as well as ensuring assessors are appropriately trained.

Conclusion

The basis for achieving consistent excellence in project management is assisted by mature organisational systems and processes. MMM is a simple yet robust model capable of guiding the development of any project management environment that needs to support the business of successful project, program and/or portfolio delivery. It forms a bridge between organisational strategy and project success through compatibility with the *PMBOK™ Guide* and the 3D Integration Model for assessing optimal delivery of individual projects. It can be adopted as a self-assessment tool and enhanced by the employment of an experienced consultant or auditor to provide improvement advice. It is a potential replacement for the complex OPM3 tool especially for smaller organisations that cannot justify the resultant time and expense. MMM is the only maturity model that uses the PDCA continuous improvement cycle embedded in the PMBOK methodology, and the only maturity model that supports customisable organisational capabilities. Field-testing on a medium-sized firm in Tehran suggests the implementation of MMM in practice is feasible and considered valuable by organisational stakeholders. Despite established solutions like CMMI, P3M3 and OPM3, there is still opportunity for MMM to improve current practices.

A Microsoft Excel™ template for calculation of maturity scores is freely available from the lead author of this paper via an email request.

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APPENDIX 3

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The following page includes the PAR questionnaire.

APPENDIX 3

THE FOLLOWING QUESTIONS RELATE ONLY TO THE PROJECT DELIVERY PROCESS AND IDEALLY ARE TO BE ASSESSED BY A SENIOR MANAGER, PMO REPRESENTATIVE OR EXTERNAL AUDITOR

		SD	D	N	A	SA
A	The project manager actively managed both sponsor and end-user expectations of benefit realisation.				X	
B	Planned and actual performance was assessed regularly using earned value management.	X				
C	Inadvertent scope creep did not occur or lead to adjustment of time, cost or risk baselines.		X			
D	New ideas were routinely investigated and implemented by the project team.		X			
E	When needed, additional resources were applied in a timely manner to stay on track.				X	
F	There were no delays to critical tasks that impacted on the agreed project completion date.				X	
G	Savings were found and used to reduce the contracted project cost.					X
H	The number of variations on this project did not result in cost increases above the planned contingency.		X			
I	The quality standard achieved for all deliverables was high with few, if any, defects requiring rectification.				X	
J	There were no safety concerns or injuries recorded during project delivery.					X
K	There were no delays in the commencement of key external contracts.					X
L	The project team worked well together under effective leadership.				X	
M	All project data were digital and securely maintained and managed by the team.					X
N	Key stakeholders were provided with open and honest information concerning project performance.					X
O	Expected risk was reconciled against actual risk at the conclusion of the project.	X				
P	Positive risks were considered and embraced by the project team.	X				
Q	Suppliers and sub-contractors were satisfied with the amount and timing of remuneration for their services.				X	
R	There were no litigation or alternate dispute resolution procedures required.					X
S	Lessons learned from the project were formally recorded and discussed by the team.			X		
T	The sponsor was very satisfied with the quality of project management services.				X	
		Performance		**=**		**70%**

All questions must be answered
SD=strongly disagree (1), D=disagree (2), N=neutral (3), A=agree (4), SA=strongly agree (5)